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President Obama Visits FHWA
A Legacy of Innovation

U.S. Department of Transportation
Federal Highway Administration

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—featuring developments in Federal highway policies, programs, and research and technology—

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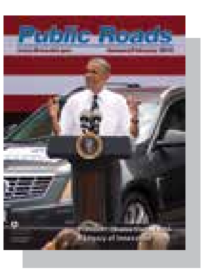

Front cover—After touring the Turner-Fairbank Highway Research Center in July 2014, President Obama spoke to an energized crowd of Federal Highway Administration employees. The President praised the cutting-edge work being done by the FHWA researchers at TFHRC to help save lives and money. For more information, see "FHWA's 'Innovations Factory' Commands Presidential Attention" on page 2 in this issue of PUBLIC ROADS. Also see the companion photo story, "Excitement Reigns During Presidential Visit," on page 8.

Back cover—Collecting data on as-built facilities traditionally required closing a roadway for surveying. But thanks to mobile mapping technology, crews now can capture data at highway speeds using multiple high-definition cameras with state-of-the-art lidar sensors that collect one million points per second, as shown in this image from Dallas, TX's Horseshoe Project. This technology is one of many innovations FHWA is advancing under its Every Day Counts initiative. For more on innovation, see "Innovations Hit the Road" on page 12 in this issue of PUBLIC ROADS. *Photo courtesy of Texas Department of Transportation and Woolpert, Inc.*

U.S. Department of Transportation
Federal Highway Administration

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Guest Editorial

Innovative Solutions for the Nation's Highway Challenges

As President Obama saw firsthand when he visited the Turner-Fairbank Highway Research Center last summer, the Federal Highway Administration (FHWA) is a world-class incubator of innovations. From the highway driving simulator and research on connected vehicles, to the ongoing pursuit of more durable construction materials and more effective paving techniques, FHWA continues to break new ground—as it has for a century or more. In a manner of speaking, innovation is in its DNA.

The research center is continuously developing and evaluating new material specifications for stronger, more durable bridges and pavements. In addition, FHWA is leading the deployment of proven innovations that save lives and build roads and bridges faster, cheaper, and with less environmental impact. This commitment to research and innovation ultimately delivers a safer, more reliable transportation system that is both effective and environmentally sustainable.

Several articles in this issue of PUBLIC ROADS focus on innovation in the highway industry at the national level. One of the articles describes President Obama's tour of the research center's laboratories where many highway innovations first see the light of day. Innovations start in the laboratory, but the transportation system never would see the benefits without the effective adoption and acceptance of these innovations into the state of the practice. Another article in this issue focuses on methods for accelerating the adoption of innovations through project demonstrations. A third article chronicles the history of highway innovation.

Various industry groups are committed to innovation as well. More than a decade ago, the American Association of State Highway and Transportation Officials (AASHTO) developed a program called the Technology Implementation Group, recently renamed the AASHTO Innovation Initiative. The American Road & Transportation Builders Association (ARTBA) sponsors a major workshop every year focused on where the industry needs to be years into the future, and what sorts of innovations will take it there. In 2013, ARTBA's TransOvation™ workshop focused on driverless vehicles and what the highway community needs to do to prepare for them.

In addition, FHWA's new Center for Accelerating Innovation is leading the agency's Every Day Counts initiative, which focuses on deploying new technologies and approaches. Deputy Transportation Secretary Victor Mendez initiated that effort in 2009 as FHWA's Administrator. Whenever the agency initiates the process of identifying the next group of Every Day Counts innovations to focus on, AASHTO, ARTBA, the National Association of County Engineers, and other groups are key players in the process.

Perhaps, therein lies the real lesson about innovation: Success ultimately hinges upon cooperation. Innovations are more than just pieces of machinery or mixtures of materials. More and more, the innovations providing the most benefit are those that have to do with how well people and organizations work together. Collaborating with partners around the world, FHWA's research is improving the roads and bridges we travel on every day, saving lives, reducing congestion, and advancing economic growth.

What was once dreamed of as the highway of the future is becoming reality. And today, FHWA and its research center are moving toward solutions that will affect the transportation system of tomorrow.

Gregory Nadeau
Acting Administrator
Federal Highway Administration

President Barack Obama's visit to the Turner-Fairbank Highway Research Center highlighted 100 years of breakthrough research. The President at the wheel of TFHRC's highway simulator made national news.

FHWA's "Innovations Factory" Commands Presidential Attention

by Doug Hecox and Debra S. Elston

(Above) Secretary of Transportation Anthony Foxx welcomes President Barack Obama to the Turner-Fairbank Highway Research Center on July 15, 2014.

Virginia's hot and muggy weather on July 15, 2014, did nothing to dampen the excitement of nearly 200 Federal Highway Administration (FHWA) employees and contractors who gathered outside the Turner-Fairbank Highway Research Center (TFHRC) in McLean to see and hear President Barack Obama and U.S. Transportation Secretary Anthony Foxx.

The historic day marked the first presidential visit to TFHRC, a world-renowned facility responsible for over half of FHWA's $115 million annual research budget.

"[It] was an unbelievable opportunity to demonstrate to the President and the Nation the extraordinary work being done at the center," says Michael Trentacoste, FHWA's associate administrator for research, development, and technology, who directs the facility. "I would also characterize the visit as a 'fun' event. It's important for staff to have fun at their jobs, and I think it was fun for the President too."

While at TFHRC, the President underscored the need for Congress to pass a bill addressing the impending Highway Trust Fund shortfall. He also highlighted the continuing need for research on highway safety.

"We need to invest in America's infrastructure," Obama said. "You guys are helping to show us how to do it in a really smart way. We need to invest in American innovation and research and development . . . all these things would make a difference in people's day-to-today lives."

Before the speech, Trentacoste gave the President a tour of the facility, which is home to more than 24 indoor and outdoor laboratories where researchers are developing innovations in highway safety and other improvements to transportation operations. FHWA's ongoing commitment to research and innovative technology, which began a century ago, continues to change the way roads and bridges are designed, built, operated, and maintained.

"He was very personable and picked up quickly on our excitement for what we do," says Trentacoste. "I've been blessed working at USDOT [the U.S. Department of Transportation] for over 35 years, and I've met all the U.S. transportation secretaries since Brock Adams—but meeting the President is certainly a capstone event."

TFHRC Director and Associate Administrator for Research, Development, and Technology Michael Trentacoste thanks Mr. Obama for his address to the center's workforce.

Driving the Simulator

David Yang, leader of the human factors team in FHWA's Office of Safety Research and Development (R&D), showed the President FHWA's highway driving simulator—a popular feature at the center—and the only one of its kind in the world.

The simulator consists of a full automobile chassis surrounded by a cylindrical projection screen onto which three projectors render a seamless 200-degree field of view that shows high-quality computer-generated roadway scenes. Its six degree-of-freedom motion-based system provides pitch and surge (for acceleration and braking), lateral, roll, yaw (for curve and turning forces), and heave (for bumps), which are all synchronized with the onscreen imagery. The simulator's sound system provides engine, wind, and even tire noises.

"FHWA's state-of-the-art simulator is one tool we use in our human factors research to better understand driver behavior and test innovative roadway designs and operation scenarios," says Monique Evans, director of FHWA's Office of Safety Research and Development.

The President quipped that it was the first time that he had driven a car, relatively speaking, in 6 years.

"This is so exciting," the President told onlooking reporters, while buckling his seatbelt. "I haven't been on the road in a long time." Later, in his speech, he described the experience as "sort of like 'Knight Rider,'" in reference to a popular television series in which a crime fighter drives an artificially intelligent supercar.

He added, "As the father of a daughter who just turned 16, any new technology that makes driving safer is important to me. And new technology that makes driving smarter is good for the economy."

Next on the Tour

Taylor Lochrane, a research engineer with the TFHRC team that analyzes transportation operations, briefed President Obama on the center's ongoing research into vehicle-to-vehicle and vehicle-to-infrastructure integration. Lochrane also showed the President the technologies that researchers are installing in FHWA's vehicle fleet in order to test applications that could improve safety, mobility, and environmental efficiency. These technologies are leading to a future filled with driverless vehicles and safer, more efficient highways.

"It was an amazing opportunity to discuss with him the value of the research we do, specifically the areas of connected vehicles and connected automation," Lochrane says. "We talked about the new technologies being tested, and we laughed about where the spare tire would go—because, with all the gadgets we put in the test vehicle, we had to remove the spare. I really enjoyed my conversation with him. It was a once-in-a-lifetime experience."

Director of FHWA Operations R&D Joe Peters, who gave the President a tour of the facility's Saxton Transportation Operations Laboratory, agrees. "The President and I discussed traffic congestion problems, and the fact that we can't *build* our way out of them. Because congestion costs our country over $120 billion a year, I told him we had to use the roads we have more efficiently and turn to new telecommunications technologies,

Dr. David Yang, Human Factors team leader in the Office of Safety R&D, accompanies President Obama to the driving simulator for a demonstration of how one aspect of connected vehicle technology might work.

such as those being developed in USDOT's connected vehicle program," says Peters. "The President was intrigued by our work."

Evans adds, "We are so focused on solving problems, creating new knowledge, and developing new technologies that we often neglect to regularly toot our horn about our achievements. Simply meeting the President has been on my bucket list for several years, but I never imagined being able to tell him how the products of our research and technology efforts are improving safety—or to get a hug from him afterward! It was unquestionably one of the highlights of my career."

Before the President left, he was promised a sample of another highly prized TFHRC product: honey. For nearly 6 years, TFHRC has been home to 100,000 honeybees, which support President Obama's efforts to prevent "colony collapse." At the President's direction, beehives also were added to the south lawn of the White House in 2010.

"If the President knew he was that close to thousands of bees," says Matt Gaillardetz, TFHRC's network systems manager and resident beekeeper, "he certainly didn't show it."

A Century of Highway Research

The tour demonstrated that the value of the research conducted at TFHRC continues to be important. Engineers, scientists, and others around the world use TFHRC to advance research for USDOT, State and local governments, industry, associations, and others, including the National Academy of Sciences and the National Transportation Safety Board. Currently, more than 300 Federal employees and dozens of contractors, guests from international partners, graduate students, and postdoctoral professionals use the facility.

For better than a century, moreover, TFHRC and its forebears have conducted innovative studies into road use and construction.

At the start, the U.S. Department of Agriculture's (USDA) Department of Chemistry formed a Road Material Laboratory in December 1900 to support testing needed by the Office of Public Road Inquiries, FHWA's earliest ancestor. In the years that followed, the automobile was supplanting the horse and buggy as the Nation's vehicle of choice. As the country's nascent automobile industry grew, so did the demand for research to help establish an organized network of high-quality roads. (For more on the history of transportation research and innovation, see "How the Uncommon Became the Commonplace," on page 18.)

Throughout the country, bad roads were the norm. Part of the reason was that local officials lacked the training needed to build and maintain roads properly, but also there was a lack of research and road-building literature. According to an editorial in *The Washington Post* in 1919, "The result was a crazy quilt of roads, beginning nowhere and ending in much the same general location, built to conform to no particular standard and generally serving no particular aim."

The advent of heavy commercial trucks soon proved problematic for roads built to accommodate buggies, wagons, and lightweight cars like the Model T. In 1920, the USDA's renamed Bureau of Public Roads (BPR) constructed a roadway at its Arlington experimental farm to test a variety of pavement materials and construction techniques.

Subsequent research expanded into traffic operations and laws.

"Regulating traffic is in a far from satisfactory condition, taking the country as a whole," said Herbert S. Fairbank, a senior highway engineer with BPR in 1922. "Each of the States has adopted its own regulations without much regard for the regulations of adjoining States, with the

Taylor Lochrane, research civil engineer at TFHRC, explains the hardware installed in the research vehicles that are used in testing connected vehicles in the real world.

Leading the Way on Roads

Throughout history, public leaders have taken a strong interest in roads and highways—from Julius Caesar and Napoleon to President Thomas Jefferson, who funded the National Road—the Nation's first highway—in 1806. Here are some other examples.

President Harding is shown here at a podium on the Ellipse south of the White House in June 1923, where he dedicated the Zero Milestone.

President Warren G. Harding. When President Harding dedicated the Zero Milestone at the White House on June 4, 1923, it was to serve as the central point for measuring all distances in the United States, like the Golden Milestone in ancient Rome. In 1919, a temporary marker was dedicated at this spot for the kickoff of the U.S. Army's first motor vehicle convoy across the country. A young officer, Dwight D. Eisenhower, missed the ceremony but joined the convoy in nearby Frederick, MD. The experience left a lasting impression on him, which proved vital to the country when President Eisenhower signed the Federal-Aid Highway Act of 1956 into law.

President John F. Kennedy. The Northeastern Expressway (also called the Delaware-Maryland Turnpike, and now part of I–95) opened on November 14, 1963, with President Kennedy cutting the ribbon before a crowd of 10,000. The new road, the President said, "symbolizes the effort we have made to achieve the most modern interstate highway system in the world." It was the only time a President has participated in an interstate opening. Eight days later, he was assassinated. In his honor, officials renamed the turnpike the John F. Kennedy Memorial Highway in 1964.

In this photograph from November 1963, President Kennedy is cutting the ribbon to open the Northeastern Expressway connecting Delaware and Maryland.

President Lyndon B. Johnson. President Johnson was on hand on May 11, 1965, to wish his wife and others well on their Landscapes and Landmarks bus tour to promote his own America the Beautiful campaign before the opening of the White House Conference on Natural Beauty 2 weeks later. The bus tour began at 8:30 a.m., prompting the President to grumble about the early hour before telling them, "Y'all have a good time." The experience contributed to the passage of the Highway Beautification Act 5 months later.

Early on a May morning in 1965, President Johnson is seeing off a bus tour to promote his America the Beautiful campaign.

result that when a motorist passes from one State to another, he must learn almost an entirely new code."

One of the reasons for this lack of uniformity, he added, is that there had not been enough experimental research conducted upon which to base regulations, such as speed limits, road strength, wheel load, and even tire width.

By the late 1920s, a great boom in roadway construction had begun, resulting in nearly two dozen highways crisscrossing the Nation. Awareness of the value of highway research was increasing.

A New Center for Research

To accommodate the growing need for road studies, Congress authorized the purchase of 581 acres (235 hectares) in McLean, VA, in 1938, freeing up the existing Arlington experimental farm for construction of the Pentagon and Reagan

Dr. Joseph Peters, director of the Office of Operations R&D, explains the center's ongoing connected vehicle research.

National Airport. Construction of two buildings at the site selected by Congress for BPR's new research facility began with a mechanical shop and a heating plant soon after. But construction was stopped in 1941 to make resources available for the war effort. It wasn't until the early 1950s that the first buildings, then known as the Langley Research Station, were ready for occupancy.

In 1964, the facility was renamed for Herbert S. Fairbank, a highway research pioneer in the 1920s who became BPR's deputy commissioner for research and played a role in the birth of the interstate system. Plans to expand the facility took root in 1967, and construction of a new building began in 1980. That building was named for Francis C. Turner, who served as BPR's director and later as Federal Highway Administrator.

When the $6.5 million three-story Turner building opened in 1983, it expanded the research facility by 80,000 square feet (7,440 square meters) of offices and service space. The new building provided conference areas, a human factors laboratory, and additional lab space to accommodate research into pavement components, road and bridge structures, hydraulics, experimental vehicles, and highway noise.

The facility's structures laboratory—now more than 30 years old—remains a marvel of engineering innovation. Its floor, composed of a four-celled structural box girder, is fully instrumented to help researchers study internal stresses of test specimens placed under heavy loads. At maximum, the lab can exert up to 2 million pounds (907,185 kilograms) of force on bridge elements, which enables researchers to test years' worth of stress and fatigue in only days or weeks.

Recent and Ongoing Innovation

TFHRC's work, which began in the early 20th century with the study of farm roads, grew over the decades to research, development, and testing of a dizzying array of technical innovations, such as new pavement materials, bridge and highway designs, retroreflective materials that make signs and pavement markings brighter, robotic bridge inspectors, crash-testing of roadside safety hardware, and technologies that enable vehicles to "talk" to each other and surrounding roadway infrastructure. The research at TFHRC stands to be as important to the roads of this century as it was to the last.

"From developing infrastructure capable of meeting future energy demands to improving safety and mobility through connected vehicle technology," says Trentacoste, "FHWA research is trying to stay ahead of technological advances and to anticipate the highway challenges of tomorrow."

Among the studies currently underway, TFHRC engineers are researching productive roadways to help advance domestic energy production, storage, and distribution.

"Imagine using the public right-of-way, traffic signals, or even the road surface itself as a source of energy," says Trentacoste. "Our Exploratory Advanced Research (EAR) program is doing just that," he adds, through a roadway wind/solar hybrid power generation and distribution system. Another project, one of many funded through the Small Business Innovation Research grants program, is exploring the potential use of roads themselves to collect and store solar energy.

Recognizing the value of the research conducted at the center, President Obama said in his address, "America has to invest more in the kind of job-creating research and development that you're doing right here at the highway research center."

"The future is now," he says, "and we are addressing current roadway issues as well as emerging challenges in a variety of areas."

In addition to breakthrough concepts in materials science, motorist behavior, and travel choices, researchers at TFHRC are putting cutting-edge science to use in keeping roads safer and making them more durable. The center's research even includes nanotechnology, which may one day lead to more effective bridge maintenance.

The Future of Highway Research

The President's visit centered on TFHRC's work on connected vehicle technology, which may help advance the reality of driverless cars and improve safety and mobility for millions of travelers.

"The realization of connected vehicles, and connected automated [driverless] vehicles, in our country," says Peters, "would be the equivalent of a moon shot that will revolutionize our transportation system as we know it. It could make our Nation much more productive, increase our mobility, create jobs, save lives . . . and save fuel while sustaining our environment."

With more than 600,000 bridges and nearly 9 million lane-miles (14.5 million kilometers), the U.S. system of roads, bridges, and interstates is often called the backbone of the world's most powerful economy. There is more than a grain of truth to that. The United States depends on a reliable network of roads to move people and goods across the country efficiently and safely, and research will help to keep it that way in the years ahead.

Despite the highway system's age and the increased volume and weight of traffic, the network must continue to promote public safety and facilitate commerce by making trips to work and other destinations faster and safer.

In 2012, more than 33,000 people died in crashes on U.S. highways. Although fatalities have declined annually, FHWA research is continuing to pursue innovations that support USDOT's goal of zero deaths and serious injuries on U.S. roads. To this end, despite the last century's multitude of technological advances, the agency's research mission remains fundamentally the same: innovation.

"One of the principal objectives of the 1893 Office of Road Inquiry, the forerunner of FHWA, was to foster research in highway design, highway materials, and other such matters that needed attention in that era," Turner told the U.S. Senate Committee on Public Works in 1970. "The need for new ideas and new concepts for bringing about better highway transportation has by no means diminished during the ensuing years. The Nation has looked to the Federal Government to provide leadership in matters of highway research.

"This has been accomplished over the years, not by spectacular developments, but by steady dedicated effort . . ."

During President Obama's recent visit, he echoed those thoughts. "The cutting-edge research that all of you are doing here helps save lives and save money, and leads to new jobs and new technologies and new industries," the President said. "And that's why America has to invest more in the kind of job-creating research and development that you're doing right here."

Trentacoste agrees. "Our research and technology are transforming today's big ideas into the innovations our Nation needs," he says. "TFHRC is what it has always been—an innovations factory."

Doug Hecox is a spokesman with FHWA's Office of Public Affairs. He has a journalism degree from the University of Wyoming, teaches journalism and public relations writing at American University, and has authored two books.

Debra S. Elston is director of FHWA's Office of Corporate Research, Technology, and Innovation Management. She provides leadership and direction for the coordination, collaboration, and communication of the Agency's research and technology program. Elston has a degree in business administration from MidAmerica Nazarene University.

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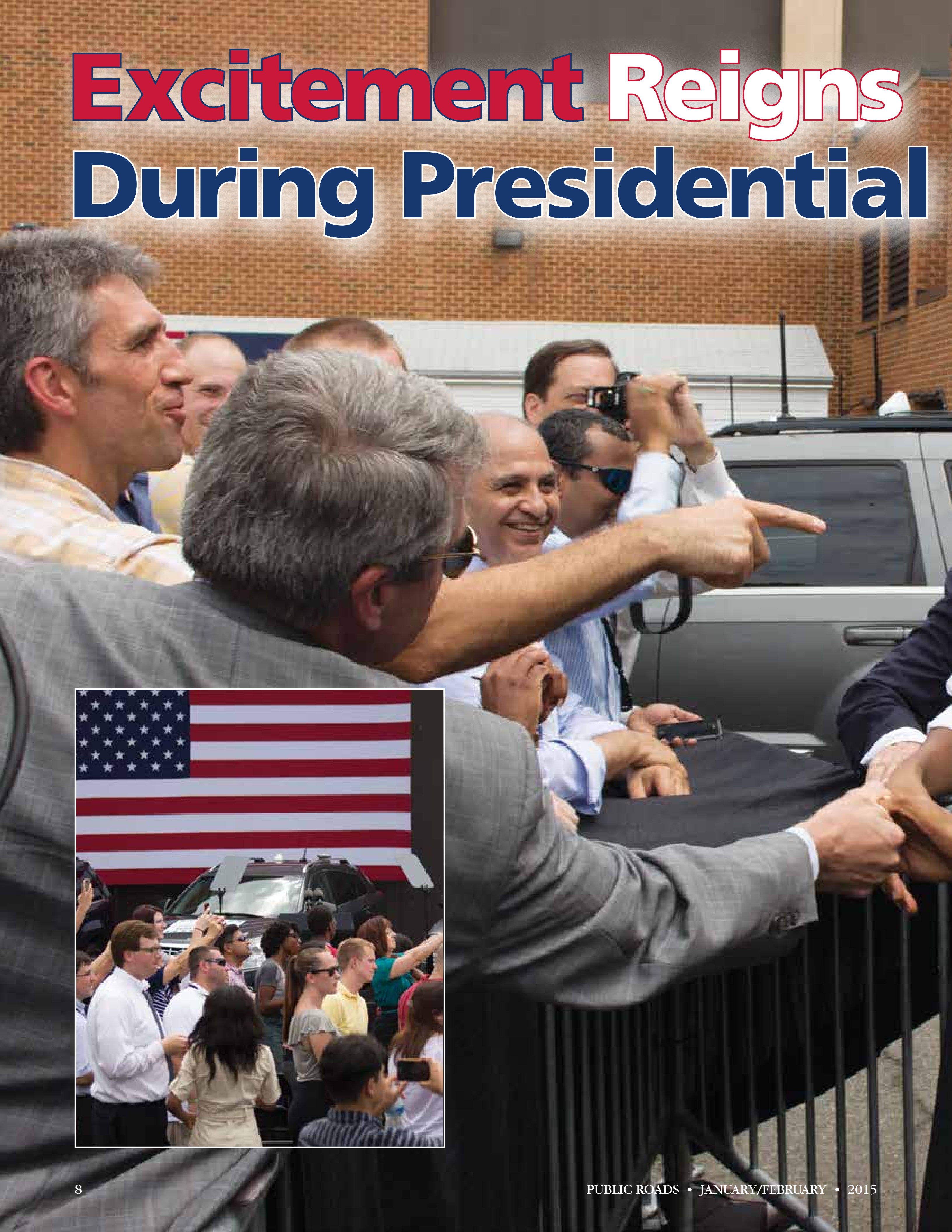
At the Office of Operations R&D, answering the President's questions are (L-R): Julie Evans, research assistant; Deborah Curtis, transportation specialist; Ben McKeever, team leader, transportation operations applications; Joe Bared, team leader, transportation operations concepts and analysis; Gene McHale, team leader, transportation enabling technologies; and Joseph Peters, director of the Office of Operations R&D.

Excitement Reigns During Presidential



*by Doug Hecox
and Debra S. Elston*

Visit

President Barack Obama's tour of FHWA's Turner-Fairbank Highway Research Center offered a once-in-a-lifetime experience for TFHRC employees.

Photographs by Doug Hecox, FHWA, and Dan Wolfe, TFHRC.

(Above) Shaking hands with the President is transportation engineer Peng "Patrick" Su, a contractor with the Saxton Transportation Operations Laboratory.

(Left) The President greets an enthusiastic throng of TFHRC employees.

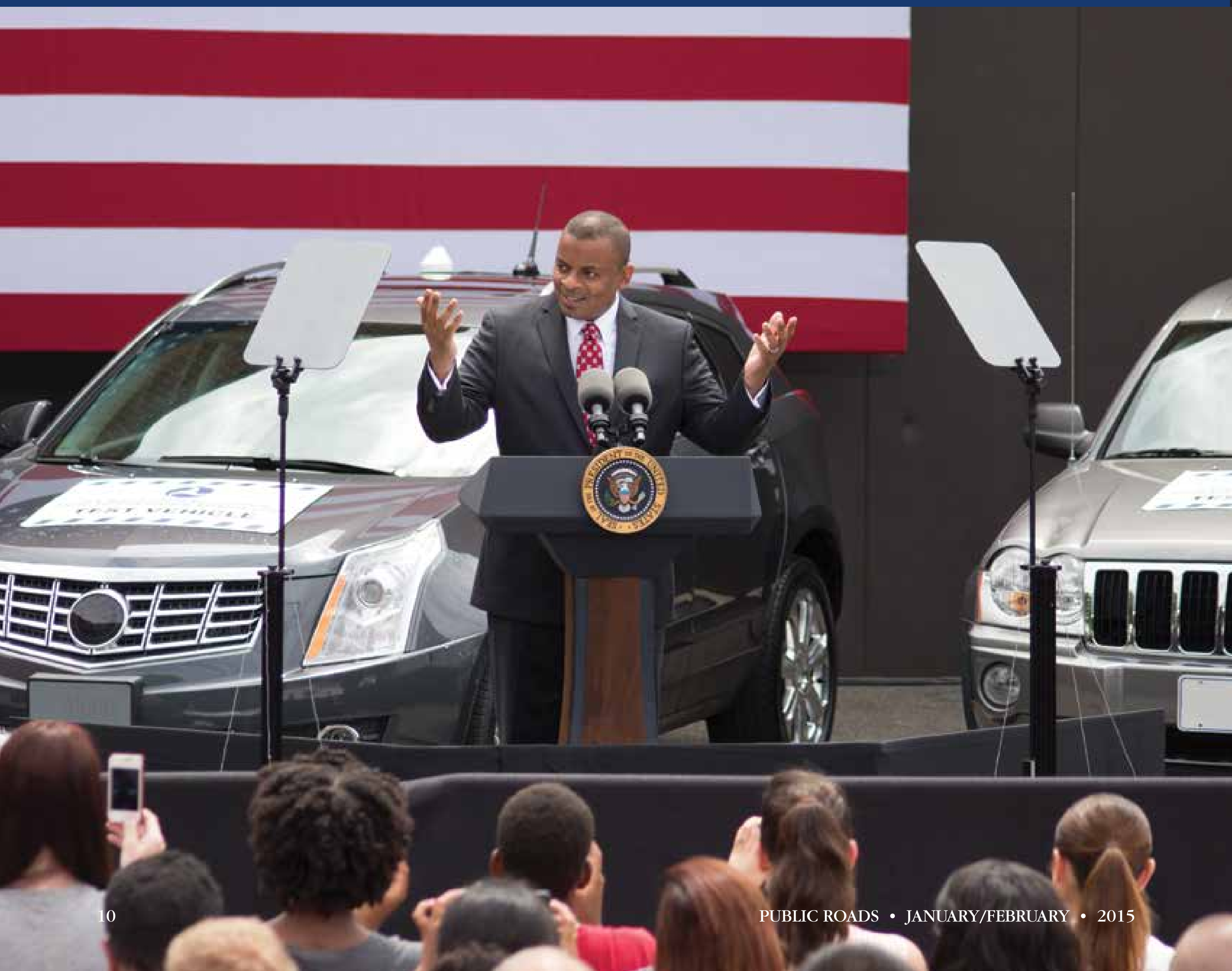
(Inset) After waiting in the hot July sun, TFHRC staff eagerly anticipates the arrival of President Obama.

(Below) The President shakes hands with TFHRC employees. On the left is LaKesha Perry, a chemist technician, and next to her is Lisa A. Shuler, team director, Innovation Management and Communications.

Surrounded by news crews, the President follows Dr. David Yang, Human Factors team leader in the Office of Safety Research and Development, to the driving simulator.

The President shakes hands with electronics technician Christopher Huffman, a contractor at TFHRC.

Secretary of Transportation Anthony Foxx discusses the potential of connected vehicle research prior to introducing the President.



The President meets more TFHRC employees.

Meeting the President is (left to right) Jussara Tanesi, manager of the Concrete Lab. Next to her is Raghu Satyanarayana, a program manager; Chandni Balachandran, a research chemist; and Heather Mathieson, a technical editor.

The President greets David Tchaou, a student attending a 3-day Transportation Summer Mini-Camp at TFHRC. In addition to meeting the President, Tchaou and five other students received hands-on training in transportation research at several of TFHRC's laboratories.

Innovations Hit the Road

by Mary Lou Ralls, Bruce Seely, Ewa Flom, and Randy Brown

Project showcases are a powerful tool for converting the skeptical. If you have doubts about some new technology, these success stories might change your mind. Join the domino effect.

In a positive domino effect, one showcase leads to another. Representatives of the Rhode Island Department of Transportation attended a Florida showcase and then held their own a few months later. At their event, they showed how this prefabricated steel bridge was deployed using self-propelled modular transporters for the I–195 relocation project in Providence, RI.

It's one thing to explain to someone the benefits of an innovation on a construction project. It's quite another to convince them to take the leap of actually using it.

All too often, the risks involved in trying something innovative can keep organizations and individuals from experimenting with a new procedure or technology. Project showcases are proving to be a key tool in bridging the yawning gap between risk and experimentation. Technology showcases enable professionals responsible for highway programs to stand on the sidelines of someone else's project and watch as the innovation is applied, see the real-world challenges, and question those involved, one-on-one, about concerns—all without any commitment or risk.

At a September 24, 2013, showcase featuring slide-in bridge replacement technology, hosted by the New York State Department of Transportation (NYSDOT) in Westchester, NY, one participant observed, "This was a new concept to me, and it was great to have the opportunity to hear the contractor, the owner, and the consultant inspection firm share their experiences first hand." Said another, "It helped shape my ideas about when this type of project would be beneficial."

Multiply that individual level of enthusiasm by the several thousand other people in the highway community who have participated in showcases, and you'll understand why project showcases are such a powerful tool. Attracting designers, builders, and owners of highways and bridges to someone else's jobsite where a real project is being constructed enables the participants to see the unvarnished reality of the innovation's benefits. Brochures and videos might not be clear, and presentations can overlook potential problem areas, but seeing is believing.

What Are Project Showcases?

Showcases are special events built around projects that use particular design or construction innovations. They bring together highway professionals—usually from other cities, counties, States, or countries—to witness for themselves how the new approach works in actual practice.

A typical showcase might begin in the morning with a series of presentations in a hotel conference room or public facility near the project site, aimed at familiarizing visitors with the technology and providing them with a context for the construction project they will visit later. The owner agency's project manager, construction contractor, design consultant, or others involved in the project each give their perspectives of project-specific problems encountered and how the innovation helped address those concerns. In addition, the presentations often include discussions by national experts about the particular innovation, as well as talks about other projects where the innovation was used successfully.

After the presentations and questions from the audience, the group moves from the meeting room to the project site. In some cases, because of how construction is timed to accommodate traffic, organizers may schedule site visits late in the evening or very early in the morning. Visitors often see activities and details onsite that bring up additional questions, and the professionals who presented earlier are on hand to respond.

As a visitor to the I–84 Echo Frontage Road bridge replacement showcase held in Park City, UT, August 17–18, 2013, stated, "The site visit provided real and valuable experience. [That experience] could not be duplicated through a [PowerPoint], webinar, or presentation." The showcase featured two innovations: slide-in bridge construction and the geosynthetic reinforced soil–integrated bridge system.

More than 11,000 highway demonstration projects having cumulative construction costs of more than $40 billion have occurred since 1970, and dozens of these have been showcased. The innovations used on these projects have ranged from simple changes in pavement mixtures to replacement of entire bridges.

Although the innovations that these showcases highlight might be new, the overall approach is not. Demonstration activities emerged during the earliest years of the Federal highway program and have been a hallmark of the Federal-aid approach ever since.

The Beginning

From its origins in 1893 as the U.S. Department of Agriculture's Office of Road Inquiry, the Federal road agency has found innovative ways to showcase success stories. For more information on the history of innovation showcases, such as object-lesson roads and Good Roads Trains, see "How the Uncommon Became the Commonplace" on page 18 in this issue.

As State transportation agencies grew in size and sophistication, it made sense to have the owner agencies themselves host showcases, using their own projects as case studies. Showing often proved to be a more effective way to convince State and local officials than writing about what to do. It helped them adopt new ideas and adapt to change without creating resentment. In fact, it helped turn the hosts of the demonstration events into advocates of change.

Showcases Today

When a project used for a demonstration is the first time that a sponsoring agency has applied that particular innovation, any anticipated time and cost savings may be lost due to the learning curve faced by agencies, designers, and contractors. The sponsoring agency also might have concerns over the financial risk involved with doing something different.

Potential participants in a project showcase in DeLand, FL, received this invitation. The photo on the front shows a self-propelled modular transporter lifting a prefabricated bridge span.

Therefore, a critical element in the success of a program that relies on demonstrations has been to provide the owner agencies with supplemental funding. Under the Moving Ahead for Progress in the 21st Century Act (MAP-21), the Technology and Innovation Deployment Program includes grants through the Accelerated Innovation Deployment (AID) Demonstration program. Although the AID Demonstration program has funds specifically dedicated to demonstration projects, such projects do not have to fall under the area of construction. They can involve planning, finance, environment, design, materials, pavements, structures, and operations. More details on the AID Demonstration program can be found at www.fhwa.dot.gov/accelerating/grants/index.cfm.

Helping Transform Bridge Construction

How have project demonstrations transformed specific innovations? Showcasing innovations in accelerated bridge construction is a good example.

Cases in point: high-performance concrete, prefabricated bridge elements and systems, the use of self-propelled modular transporters or lateral slides for superstructure moves, and geosynthetic reinforced soil–integrated bridge systems. Each of these has had numerous showcases to provide the opportunity for structures specialists to see for themselves how these innovations work and how agencies can benefit.

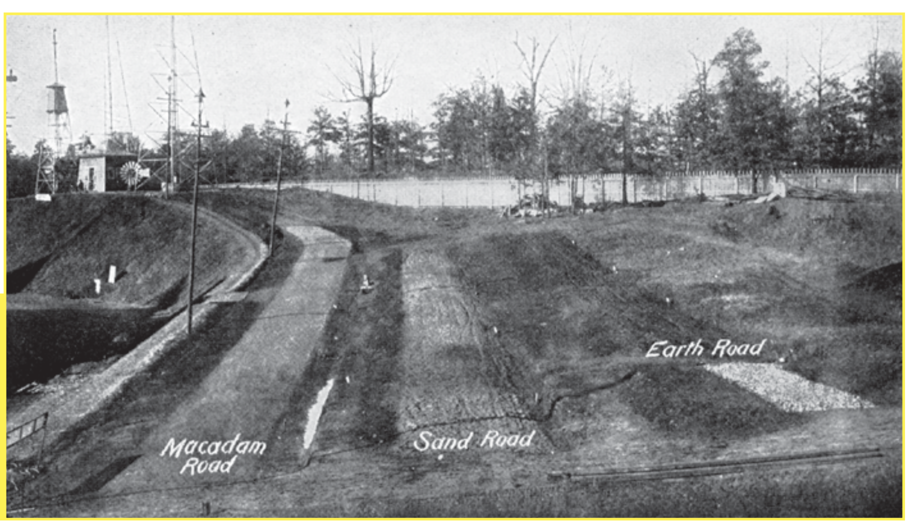
For example, in 1996, the Federal Highway Administration (FHWA), the Texas Department of Transportation (TxDOT), and the Center for Transportation Research at the University of Texas at Austin cosponsored a workshop and showcase to promote high-performance concrete. The activity focused around the Louetta Road Overpass in Houston, TX, the first U.S. bridge to have high performance concrete in its superstructure and substructure. High-performance concrete has a longer life and more durability than other kinds of concrete. The showcase included dissemination of information about the concrete itself; a presentation of products available; an exchange of ideas among representatives of local, State, and Federal government agencies, the construction industry, and the academic community; and a tour of the overpass project site.

The Georgia Department of Transportation (GDOT) sent several engineers to the showcase and FHWA's Georgia Division bridge engineer also attended. After the event, the group returned to Georgia and did a pooled-fund study using Georgia aggregates. Paul Liles, GDOT's Assistant Division Director of Engineering, said, "The benefit we got from attending the Texas high-performance concrete showcase was learning that Georgia could use [the concrete] in its bridges. We just had to work out our aggregates as compared to Texas aggregates."

As is often the case, Georgia's success resulted in GDOT sponsoring a showcase of its own in March 1997 in Atlanta. That workshop included participants from Florida, Georgia, Tennessee, and four other States. Shortly after the showcase, Georgia started using high-performance concrete in its projects as a Special Provision.

One-Hour Bridge Placement

The deployment of the prefabricated bridge elements and systems technology and self-propelled modular transporters was even more dramatic. After participating in an international scan on these technologies, William Nickas, then the State structures design engineer with the



U.S. Department of Agriculture

This 1895 photograph shows the first highway sample roads built by FHWA's predecessor, the Office of Road Inquiry, in Atlanta, GA. In this case, the office hoped to show the virtue of more expensive and permanent types of road construction.

Bridge specialists from several States and Canada attended a showcase in DeLand, FL. Some of them are shown here visiting the Graves Avenue bridge project site.

Florida Department of Transportation (FDOT), opted to use the technologies on a bridge replacement. In 2006, FDOT and FHWA cosponsored a showcase in DeLand, FL, that featured the accelerated removal and replacement of two bridge spans on Graves Avenue, spanning I–4. Using the innovations required a change order to the already existing contract, which cost the State an additional $560,000. But the detour on Graves Avenue that would have been in place in 12 months required only 8 months, meaning that the project was completed in time for the start of school; lane closures on I–4 dropped from 32 nights to only 4; and user cost savings from avoiding delays totaled $2.2 million.

The Florida showcase took place over a weekend. The program, from 1 to 6 p.m. on Friday, consisted of presentations and panel discussions in a hotel conference room, followed by a bus trip to the project site for a daytime tour. There, on a parcel of land adjacent to the site of the old bridge, which had been removed the weekend before, the participants viewed the new superstructure constructed from prefabricated bridge elements and systems and saw a demonstration of self-propelled modular transporters. At 10 p.m. on the following (Saturday) evening, attendees returned to the site to view the new bridge span being lifted and dropped into place. The self-propelled modular transporters moved the span to its final location in less than an hour.

Highway engineers from several State departments of transportation and Canada attended the showcase. The then director of project development and chief engineer for the Utah Department of Transportation (UDOT) took a delegation from his State, including UDOT engineers and staff, construction contractors, and consultant designers. The group returned to Utah and began the process of employing the technology they had seen at the showcase. In October 2007, they installed the 4500 South Bridge over I–215 in Salt Lake City using self-propelled modular transporters.

Showcases Expand Across the States

From there, UDOT began the process of making the new accelerated approach to bridge design and construction the standard for Utah. By January 2014, the agency had built more than two dozen precast superstructures using self-propelled modular transporters, and used various accelerated bridge construction methods and elements more than 230 times.

Other States had similar results. Wayne Seger, director of the Structures Division with the Tennessee Department of Transportation (TDOT), also attended the Florida showcase. He says, "The showcase itself was very valuable in that attendees were given both the contractor's perspective and comments as well as the State's perspective on the project. The contractor shared the challenges he faced in constructing the superstructure spans . . . and how he used the self-propelled modular transporters to haul the new span."

How enthusiastic was Seger? "I was excited to bring this technology to Tennessee when I returned to my office the following week. It's like getting a new tool for Christmas—you can't wait to try it out. . . . The showcase filled me with enthusiasm to share this technology with my people as well as the administration—I experienced a self-propelled modular transporter move, and it really works and is very exciting."

As a result, TDOT is now developing projects using accelerated bridge construction techniques. The agency has a project with four bridge

In addition to visiting a job site, these participants at the Florida showcase attended presentations by the project management and the contractor team.

replacements requiring acceleration on the I–40/I–65 loop around Nashville, and a potential bridge move using self-propelled modular transporters on the drawing board. TDOT is planning to complete the bridge replacements using prefabricated bridge elements and a construction manager/general contractor method for project delivery. Says Seger, "The department and the commissioner are very interested in doing more accelerated bridge construction work."

Meanwhile, as UDOT developed its expertise in this area, it too began holding showcases. Representatives of the Massachusetts Department of Transportation (MassDOT) attended and, in 2011, developed a project using modular decked beams. The megaproject involved replacing 14 superstructures on I–93 through Medford over 10 weekends (see "The Fast 14 Project" in the May/June 2012 issue of PUBLIC ROADS).

MassDOT hosted a demonstration showcase on the Fast 14 Project in 2011. The Vermont Agency of Transportation (VTrans) sent five project managers from the agency's newly formed accelerated bridge program. Wayne Symonds, the State structures design engineer, says, "We used it as an opportunity to team build and to make many connections with MassDOT. In the evenings we discussed a lot of what we learned individually and discussed how we could implement those lessons in Vermont."

The timing of the Massachusetts showcase was fortunate. Says Vermont's Symonds, "The Fast 14 bridges are pretty standard superstructure-type replacement and construction, and that is where we see the most potential for accelerated bridge construction in Vermont. Tropical Storm Irene followed the Fast 14 showcase by a couple of months. We have designed and constructed a number of bridge replacements for bridges damaged or destroyed during Irene."

Clearly, project demonstration showcases have played a key role in transforming how bridges are constructed in the United States. And, thanks to this approach, many other technologies are getting deployed faster.

The Future

What's next for showcases? With more limited budgets, more restrictive travel policies, and the impact of heightened security measures on travel, whether the concept can survive is an obvious question.

One possibility is that the next phase may be virtual reality showcases, where participants can visit a project site via computer without actually leaving their offices. Animation and 3–D virtual reality modeling is already so lifelike that the movie industry has been using it to blend in things previously impossible to put on a screen. Video games have become so realistic that professional football and baseball players are using them to study the actual playbooks of their own and opposition teams.

For several years now, training programs have been available that use virtual environments and platforms to teach such subjects as maintenance programs for nuclear power plants and flight training for pilots.

More recently, developments in both software design and hardware have made the idea of sharing space in virtual reality at a reasonable cost a realistic possibility. Earlier in 2014, Facebook spent $2 billion to purchase Oculus Rift, a company that created a cost-effective headset that enables wearers to feel as if they are actually in a different environment. Currently, its use is limited to video games, but the potential is huge. As Alex Sarnoff, CEO of the manufacturer Control VR, said in a June 2014 interview with *Forbes*, "Gaming is just a start. Where can you take this beyond video games? When you think about social media and where it's gone, [you can] imagine two different people across the world joining each other in a virtual environment. You can put two people in the Sistine Chapel together, and we can both be looking around, all while I'm still sitting on my couch in L.A."

One might add that putting several dozen people at a virtual highway or bridge construction site for a project demonstration showcase should be just as conceivable.

Government research agencies, such as the Office of the Director of National Intelligence's Intelligence Advanced Research Projects Activity, are using Virtual Learning Environments to perform

For a demonstration showcase on I–215 in Salt Lake City, crews replaced approximately 1,500 square yards (1,250 square meters) of pavement during a nighttime lane closure. Here, workers use a handheld screed to level the base.

Showcase attendees watch as crews install a pavement panel on I–215 in Salt Lake City. During the demonstration, workers set new precast concrete pavement panels in place, leveled them via leveling screws, and grouted them with urethane before morning rush hour traffic began.

research on complex topics like recognizing cognitive biases inside interactive virtual worlds. All of these varied approaches to using virtual technology point toward a significant tipping point around the infrastructure required to support them, such as affordable and capable laptop/workstation hardware, ubiquitous Internet bandwidth to support collaboration, and the explosion of cloud-based virtual world and gaming hosting solutions. They also herald the broader acceptance of this technology as a medium that can provide significant advantages over more passive, didactic training and education materials.

Reducing or eliminating travel costs by providing virtual showcases on a 24/7/365 virtual platform enables users to collaborate in real time from anywhere in the world, with the opportunity to provide real-time information in addition to what is available at the in-person physical demonstrations. Imagine if the virtual world users were able to independently play and replay a bridge replacement animation, view it from any viewpoint around the bridge, strip away ground layers and construction material layers to observe the composition, and bring up technical documents related to the equipment, all on their screens in real time. All of these capabilities are available today in many virtual platforms, along with multiuser voice chat to support discussions and facilitate questions, text chat, and the ability to import 3–D models of transportation project equipment and environments.

The virtual showcase concept may at some point provide one more tool in the acceleration-of-innovation toolbox. And although virtual implementations or representations might never replace the value of physical onsite demonstrations, they have the ability to support them, expand access to them, and accelerate the breadth of knowledge available from them in an engaging, interactive, and visual manner. No matter what form they take, demonstration showcases are sure to continue their century-old tradition of providing highway professionals the experience of applying an innovation on a real-world project without a long-term commitment.

Mary Lou Ralls is an engineering consultant and principal of Ralls Newman, LLC in Austin, TX. She earned her bachelor's degree in civil engineering and master's of science degree from the University of Texas at Austin in 1981 and 1984, respectively, prior to joining TxDOT. At TxDOT she worked in various engineering positions before being appointed the State bridge engineer and director of the Bridge Division in 1999. Ralls retired from TxDOT in 2004 after 20 years of service and continues to advance innovative technologies, including accelerated bridge construction.

Bruce Seely is a historian of technology who focuses on transportation history—with special attention to the history of American highway development and highway policy. Currently, he is Dean of the College of Sciences and Arts at Michigan Technological University.

Ewa Flom earned her bachelor's degree in civil engineering from Florida State University and M.B.A. from George Mason University. She is a licensed professional engineer in Virginia. She has worked for FHWA for 16 years in various technical assistance, strategy development, and technology deployment areas. She is currently program manager for the Accelerated Innovation Deployment Demonstration program within FHWA's Center for Accelerating Innovation.

Randy Brown is the director of the Virtual Heroes Division of Applied Research Associates. With 25 years of interactive 3–D graphics experience and 15 years applying this technology to virtual training and education content development, he is a recognized leader in the Serious Games, Virtual Worlds, and Simulations for Training arena.

For more information, contact Ewa Flom at 202–366–2169 or ewa.flom@dot.gov.

How the **Uncommon** Became the **Commonplace**

by Richard F. Weingroff

Highway innovations that seemed impossible at one time are now like any other technological marvels, where we wonder, "How did we ever get along without them?"

(Above) Innovation often seems inevitable to later generations, as California Governor Culbert L. Olson pointed out during the opening ceremony for the Arroyo Seco Parkway. (L-R): Highway Commissioner Amerigo Bozzani, Director of Public Works Frank W. Clark, Queen of the Rose Festival Sally Stanton, Governor Olson, Highway Commission Chairman Larry Barrett, and Chief Ray Cato of the State Highway Patrol.

In the late 19^{th} century, when interest in good roads was growing after years of railroad dominance, the guiding principle was "we've always done it this way." The standard design guide was the "rule of thumb." And financing was often garnered by "working out the road tax"—the levy that farmers paid by donating a day or two each year to working on the roads in their community. The result, Professor Nathaniel S. Shaler of Harvard University pointed out in 1889, was that "the common roads are built and maintained in the most ignorant and inefficient manner."

To use a late 20^{th} century cliché, a lot of people had to think outside the box to create the modern transportation network that today's road users take for granted. Governor Culbert Olson of California had this problem in mind on December 30, 1940, during the opening ceremony for the Arroyo Seco Parkway (now part of the Pasadena Freeway) in Los Angeles, CA. He wanted to memorialize the first freeway in the West "before it fades from memory" because, "Now that we have it, and it all looks so rather simple, so obviously necessary, so wholly practical, some will ask, 'What is there so wonderful, or so bold about it?'"

Many wonderful bold ideas of the road revolution have indeed faded from memory, or more correctly, were never lodged in the Nation's collective memory. They blurred into the background, as if these innovations were always there, like mountains and rivers. Perhaps some of the ideas can be attributed to lightbulbs going off, as in cartoon depictions of inventors, but most evolved from the hard work of individuals working alone, collectively, serially, or as gears in a bureaucracy, often anonymously, to create the world of tomorrow that Americans today are lucky enough to inhabit.

Predictions Are Easy

Not long after Shaler's description of common roads, the American Press Association asked the leading men and a few women of the late 19th century to predict what life would be like 100 years hence—in about 1992 (for today, that would be about 25 years ago). In the field of transportation, the experts predicted that the government would own the railroads and telegraph lines. High-speed rail, with speeds up to 100 miles (161 kilometers) an hour, would enable passengers to eat breakfast in New York City and supper in Chicago. Goods would be transported by pneumatic tubes. Citizens would be as likely to call for their blimp as for their buggy. And, according to Chicago Mayor Hempstead Washburne, transportation problems in great cities would be solved by some new genius who was as yet unborn.

A few of the leaders queried by the American Press Association did mention roads, including one very bold individual, U.S. Senator William A. Peffer of Kansas, who went so far as to predict that roads would be improved. But none of the seers predicted, even remotely, the future of the automobile and the highway. As for that unborn genius who would solve the transportation problems in cities, the wait continues.

All of which proves that making a prediction is easy, especially if the prognosticator expects to be dead when the prediction proves false. Shaping the future is much harder.

The Innovation That Started the Modern Era

If you are a motorist who curses every passing bicyclist, you might be surprised to learn that the Nation's modern road network began as a product of the bicycle craze of the 1880s and 1890s.

The "ordinary" (the bicycle with the big front wheel) may seem primitive to 21st-century eyes, but it created a craze that swept the Nation and the world. When the "safety" became available with equal-size wheels, the revolution seemed to contemporary observers to be permanent.

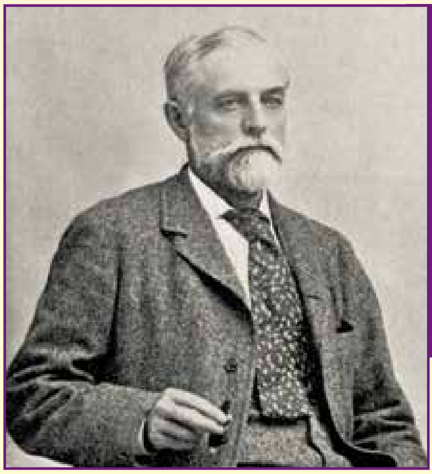
Unfortunately, the country roads that bicyclists wanted to ride on had not seen an innovation in decades. The League of American Wheelmen, bicycle makers such as Colonel Albert Pope, and league advocate General Roy Stone urged Congress to help improve rural roads, which were "hardly jackassable," to employ a cliché of the times.

In 1893, as the prognosticators longed for a genius, Congress was willing to invest only $10,000 in the Nation's roads. The appropriation was not for construction, but for a Department of Agriculture inquiry into systems of road management, the best methods of roadmaking, and the dissemination of information.

Secretary of Agriculture J. Sterling Morton selected General Stone to head the Office of Road Inquiry. With the congressional pittance in hand for anything but road-building, he described the little agency's role: "It simply furnishes a rallying point for the friends of the reform and a signal tower from which its progress can be watched and reported day by day."

In 1893, Chicago Mayor Hempstead Washburne predicted that congestion in cities would be solved by some genius who was as yet unborn. The genius was apparently still unborn in 1944 when this photograph of traffic on Second Avenue in Detroit, MI, was taken from West Grand Boulevard. Today, the country still awaits the genius.

The bicycle is so much a part of the world today that it is easy to forget that it was once innovative. Bicyclists, such as this group of Missourians, launched the Good Roads movement. Most of these riders were still using the "ordinary" (big front wheel), but the riders on the left are perched on "safety" bicycles (equal-size wheels).



General Roy Stone, a Civil War hero, worked with the League of American Wheelmen to urge Congress to fund better roads. In 1893, Congress appropriated $10,000 per year to study the subject and disseminate information. General Stone was selected to head the Office of Road Inquiry, part of the Department of Agriculture.

The Blank Slate

As has been true throughout history, people tend to adjust their lives to the pace of transportation. Over time, each innovation that the United States experienced—stagecoaches and Conestoga wagons, steamships, canals, telegraphs, the Pony Express, streetcars, and especially railroads—was hailed for its ability to shorten distances and bring a diverse country together in a union of common interest. In the 19th century, railroads were the ultimate mode of surface transportation, able to shrink the continent from months of weary travel at the speed of an ox to a mere 5 or 6 days by steam power.

As Stone began what he called a "peaceful campaign of progress and reform," rural roads were virtually a blank slate. Since the coming of the railroad, rural and interstate roads had been left mainly to the stewardship of counties and townships that cared little about them. Shaped more by happenstance and weather than plan, these roads slowed farmers trying to move produce to market, trapping them in mud, or enveloping them in dust. Moreover, the roads lacked the infrastructure that made long-distance travel possible: no direction signs, hotels, campsites, or blacksmiths for repairs.

To fill in that blank slate, Stone began what, so far, has been more than 120 years of innovation to improve roads, starting with their surfaces, and to expand the State, local, and Federal commitment to the Nation's roads. Over that span, the process of innovation included observing needs, finding ways to meet them, convincing the highway community to adopt the innovations, and, as needs changed, improving those means through an evolutionary process.

Building a Foundation For Innovation

In the months before Stone opened the Office of Road Inquiry on October 3, 1893, the country plunged into a devastating recession, the worst until the Great Depression of the 1930s. With the Office of Road Inquiry's annual $10,000 budget—only $8,000 some years in the tightened economy—Stone needed innovation just to pay for his efforts.

In today's terms, Stone relied on public-private partnerships with the League of American Wheelmen, roadbuilders, railroads, and farm groups to promote his agency's ideas. He employed innovative financing to encourage stakeholders to contribute equipment and supplies. He undertook outreach by using the government franking privilege to mail millions of brochures all over the country. And he used public involvement as he and his assistant Maurice O. Eldridge, and soon others, traveled across the country to give speeches advocating for good roads, scientific research, and the economic value of improving farm-to-market roads.

In the mid-1890s, Stone adapted a Massachusetts innovation to develop one of the agency's most successful methods of dissemination: the object-lesson road. Agents visited a city, held a good roads meeting, and demonstrated best practices by building a short stretch of road using local materials and borrowed equipment. People came from throughout the area for the speeches and demonstrations. The concept was based on the idea of "seeing is believing," in the hope that residents who used the short new road would see its advantages and encourage local officials to employ the same techniques to extend the road and build others like it. (For a modern take on technology demonstrations, see "Innovations Hit the Road" on page 12.)

Stone's successor, Martin Dodge, went further by introducing Good Roads Trains, an innovation conceived by his friend, Colonel William H. Moore of the National Good Roads Association. The trains took speakers, displays, and borrowed equipment on regional tours with stops at each major city for a good roads convention and an object-lesson road project. Railroad

This photograph, from 1901, shows crowds watching a mobile crushing plant produce macadam for a road in Winston-Salem, NC, as part of an object-lesson road project.

companies were pleased to help arrange the tours because good roads made it easier for goods to reach the railroad stations.

Selling ideas, whether by object-lesson roads, speeches, articles, convention displays, or other means, has long been a part of the Federal road agency's mission. PUBLIC ROADS is a good example. From its first issue, dated May 1918, the magazine has chronicled the evolution of road science.

More recently, the agency created the Demonstration Projects Program in 1969 to promote and accelerate the widespread adoption of the practical results of highway research and their application to innovative planning, engineering, and construction practices. The program included field and hands-on demonstrations, installation of pilot demonstrations, and workshops. Although the program no longer exists, the Federal Highway Administration (FHWA) continues to promote innovative ideas through such methods as training, webinars, demonstrations, and, of course, PUBLIC ROADS.

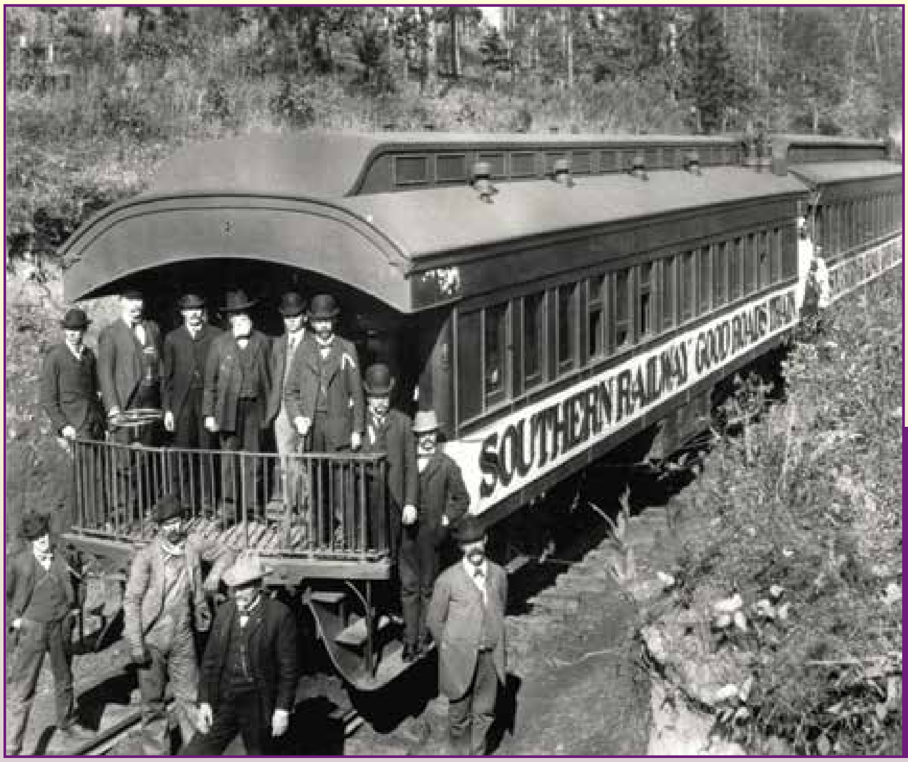
Stone and Dodge set a pattern of innovation, coupled with promotion, that their successors would adapt for their own times to explain and promote more than a century of advancements. FHWA's most recent agencywide initiative, Every Day Counts, as launched by then Federal Highway Administrator Victor M. Mendez (2009–2014), follows the same pattern of identifying needs, finding solutions, and promoting them among a broad range of representatives from State transportation departments as well as city and county agencies, and industry representatives.

Better Pavements

When the blank slate was at its blankest, the first issue was mud.

No one likes getting stuck in mud, but until well into the 20th century, being extracted from mud was a rite of passage. All road users paid the "mud tax," as their horses, mules, and wagons became mired following rain.

By the time of the bicycle craze, the best pavement for those who didn't like mud was macadam, which was named for John Loudon McAdam, a Scottish engineer and roadbuilder (1756–1836). The technique, first employed in 1816 on England's Bristol Turnpike, involved using layers of different sized stones, compacted and built above the water level, and raised slightly in the center for drainage to minimize the damage that water typically does to roads. Transportation historian M. G. Lay called McAdam's innovation a "quantum advance" over earlier techniques.



In the fall of 1901, the Office of Road Inquiry participated in the Southern Railway Good Roads Train, one of the most elaborate of the innovative Good Roads Trains of the era. At each major city, participants held a good roads convention and used borrowed equipment to build an object-lesson road.

PUBLIC ROADS Magazine: Chronicling Innovation

From the first issue of PUBLIC ROADS, dated May 1918, the magazine has been about innovation in the field of highway engineering. In a salutatory opening in the first issue, Director Logan Waller Page of the U.S. Office of Public Roads and Rural Engineering wrote that the new magazine was "dedicated to those, both in official and private life, who are concerned [about] developing means of better rural communication, . . . facilitating the marketing of the crops of the Nation, and, . . . aiding in the solution of the daily more perplexing traffic problem." The goal was to incorporate the work of those "who have in mind the ambition and at heart the desire to advance to as near perfection as possible the science of roadbuilding."

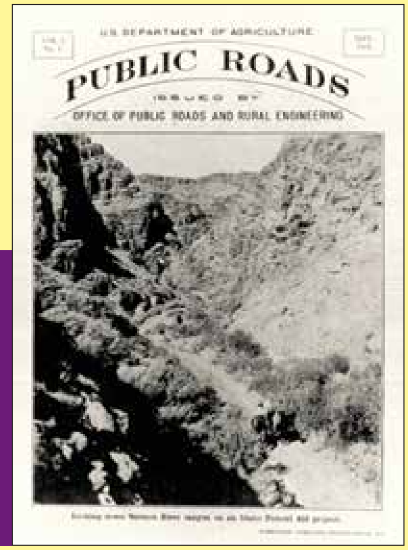
Page did not want the new magazine to be perceived as a dictator of best practices, but rather wanted his agency to use "the superior facilities at its disposition" to help the State highway agencies and others advance highway science. "It will be our earnest effort—always with the support and cooperation of the highway organizations of the States—to present matters of special interest to those directly concerned with the construction and maintenance of roads, to bring to all the progress of road improvement throughout the country, to discuss its problems and record its results."

From the start, PUBLIC ROADS has reported on innovative measures on pavements, bridges, safety, and program administration, concerns that remain today and still appear regularly as topics in the magazine. Over the years, however, the focus has broadened as the magazine, like the agency that publishes it, has focused on improving the social, environmental, and economic impacts of highways; coordinating intermodal systems; and making highways better neighbors.

As Page noted, the United States was at war in Europe in May 1918, but he hoped that PUBLIC ROADS would reflect "a determined and united disposition to bring to road betterment that which is best in and for this generation."

Ninety-seven years and several generations later, PUBLIC ROADS remains a chronicle of highway innovation.

The first issue of PUBLIC ROADS, dated May 1918, stated that the magazine grew out of "a determined and united disposition to bring to road betterment that which is best in and for this generation."



In the United States, macadam was first used in 1823 on a Maryland turnpike between Hagerstown and Boonsboro. But most rural roads remained little more than dirt paths, known as earth roads.

As motor vehicles began to travel the few expensive macadam roads in the 20th century, the pavements deteriorated quickly. As the problem made itself evident, no one could figure out how to strengthen macadam pavement to accommodate the automobile.

In 1908, Dodge's successor, Logan W. Page, blocked off a section of Conduit Road above Cabin John Bridge in Washington, DC, to experiment with pavement used by high-speed automobiles traveling at 50 to 60 miles (80 to 97 kilometers) per hour. He used still and motion picture cameras to record the effect of the tires on the macadam.

Page concluded that the "factor of destruction," especially at higher speeds, made macadam an unsuitable pavement for the auto age. In a November 1909 presentation, he said, "With this problem before us, and a rapidly increasing motor traffic, the highway engineers throughout the world are at present investigating every known material that gives the slightest promise of meeting the conditions that confront us."

Officials around the country experimented with the materials at hand, including brick, clay, gumbo (clay soil burned into ballast), limestone, crushed oyster shells, and sand-clay. The Federal road agency studied alternatives for lower priced road surfacing, as well as ways of making dirt roads more stable and less dust-prone. The Federal researchers issued publications on their findings.

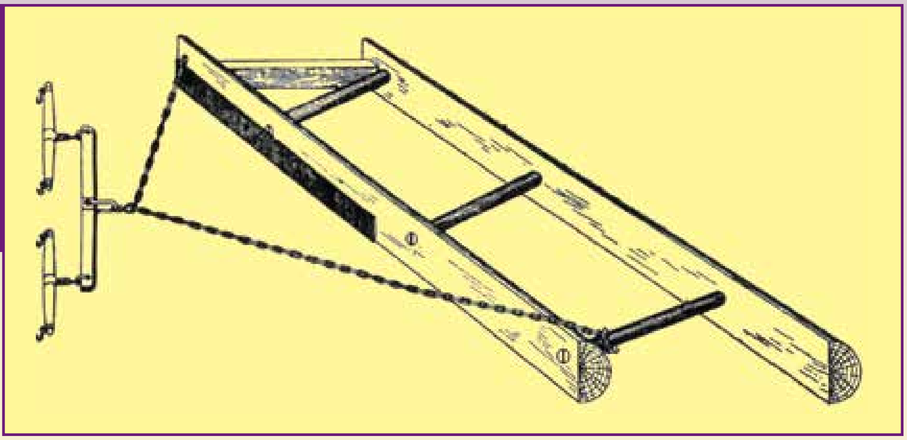
Still, earth roads ruled. When the Office of Public Road Inquiries (Dodge's renamed agency) conducted the first national inventory of rural public roads in 1904, earth roads ruled—2 million miles (3.2 million kilometers) out of 2.15 million miles (3.5 million kilometers). Only 153,662 miles (247,295 kilometers) had an added surface, such as gravel, stone, shells, or sand-clay.

Inevitably, innovators focused on the problems of earth roads, which nearby farmers periodically "dragged" smooth. In the early 20th century, a Missouri farmer named D. Ward King invented a simple split-log drag that could be made easily by any farmer. King would split a log lengthwise—diameter about 8 inches (20 centimeters)—and position the two halves, one ahead of the other and held about 3 feet (0.9 meters) apart by struts, to make a rigid platform. The lower edge of the front log held a 0.25-inch (0.64-centimeter) steel cutting plate. It cost about $2 (in the dollars of the day, of course) to make the King split-log drag, which was pulled by a team of mules or horses.

The King split-log drag was an inexpensive, easily made, and effective way of improving country roads for the usual light traffic. King traveled the country promoting his invention, with help from Page, who distributed a farmer's bulletin in 1906 about the King drag.

During this first decade of the 20th century, most automobiles were expensive, hand-crafted vehicles that only the well-off could afford. Henry Ford's innovation, the Model T, introduced in 1908, was an inexpensive vehicle designed for the times, with a high carriage to avoid scraping the ruts.

"America's love affair with the automobile," a widespread 20th century expression (used at times in admiration, other times in



D. Ward King's design for a split-log drag was easily built and just as easily used to level an earth road. This diagram is from the Department of Agriculture's 1908 bulletin, "The Use of the Split-Log Drag on Earth Roads," written by King.

disapproval), began with the Model T. It transformed the automobile industry and the way people traveled, but exposed the inadequacy of the country's roads in a way that mattered to average folk, not just the wealthy few.

In the wake of the Model T, Page continued experimenting to address broader problems as the automobile replaced the bicycle as the vehicle of choice for rural travelers. Dust was one of the biggest issues. If you have ever wondered why photographs of early motorists show them in goggles, hats, and long outer garments known as "dusters," now you know why they were essential.

Page conducted experiments to search for ingredients that could control dust. The agency tried oil, blast furnace slag, and mixing the earth with a binder such as bitumen. These experiments gradually shifted from "dust prevention" to "road preservation," and to the adoption of bituminous surfaces for rural roads, the forerunner of today's asphalt pavements. Ultimately, the solution to dust was to eliminate its cause by providing all-weather surfaces such as asphalt and concrete.

An Innovation Before Its Time

While traveling by train from Tennessee, Eldridge (now Dodge's assistant) and Representative Walter P. Brownlow (R-TN) began talking about the poor condition of country roads. They agreed that Eldridge would draft a bill based on a State aid concept first tried in 1891 in New Jersey. In December 1902, Brownlow introduced the bill, which would create a Bureau of Public Roads (BPR) to administer $20 million a year in Federal aid. Grants would be made to any State or county for the improvement of public highways "for the purposes of common traffic and travel, and for the rural free delivery of mail" outside cities and incorporated villages, with each State limited to a share of the funding equal to its percentage of the Nation's population. The State or county would pay 50 percent of the cost of the roads. The Federal Government would prepare the plans and specifications, but the State or county would administer and supervise the contracts.

As Representative Brownlow told a reporter, "Once let it be understood that the desired result can be accomplished through a system of cooperation aided, fostered, and encouraged by the general government, and then let the people of the country express themselves in favor of the plan, and you will find that Congress and the Constitution will not be against but for it."

With Eldridge secretly joining with the Automobile Club of America in support of a $10,000 publicity campaign, the Brownlow bill proved popular with almost everyone except President Theodore Roosevelt, Secretary of Agriculture James Wilson, and congressional leaders. The bill died, and when Eldridge's behind-the-scenes role was revealed, he was first fired, then rehired with a demotion.

In part because of Dodge's role in the bill, he became a victim of revenge, too. In 1905, Congress made the Office of Public Roads (not yet the Bureau of Public Roads since the Brownlow bill had failed) a permanent agency in the Agriculture Department, but specified that the director "shall be a scientist and have charge of all scientific and technical work." This language excluded Dodge, a lawyer, who

Logan W. Page, who headed the U.S. Office of Public Roads, conducted tests on Conduit Road (now MacArthur Boulevard, north of Cabin John Bridge in Washington, DC) to determine why automobile tires ruined macadam roads, the best paving surface of the horse-and-buggy days. Cameras recorded the effect of the tires, leading to the conclusion that the "factor of destruction" was too great; a new hard surface would be needed for the automobile era.

No one—not even these officials with the Office of Public Roads—could escape getting stuck in mud during the years before hard surfaces became common for the country's roads.

was replaced by Page, a scientist who was one of the first graduates of the highway engineering program that Page's uncle, Professor Shaler, had begun at Harvard.

As FHWA's bicentennial history book, *America's Highways 1776–1976*, put it, Dodge and Eldridge had "pushed a right idea before its time."

A Series of Innovations

The Federal-aid highway program is an innovation, or more accurately, a series of innovations that started with the Federal Aid Road Act of 1916 and continued, thus far, until 2012's Moving Ahead for Progress in the 21st Century Act.

The Federal Aid Road Act of 1916 created the Federal-aid highway program along lines suggested by Representative Brownlow and Eldridge. It differed in making States, not counties, the primary partners and giving them responsibility for selecting, designing, and constructing Federal-aid highway projects, subject to agency oversight.

Since then, the program has required a number of innovations to survive into the 21st century. A few of those milestones include focusing funds on designated systems of roads (1921), adapting the program to job creation during the Depression, expanding into cities (1930s), designating a National System of Interstate Highways (1944), and dedicating highway user taxes to pay for the construction of the interstate system and other Federal-aid highway projects (1956). Others include requiring a continuing, cooperative, and comprehensive planning process in metropolitan areas (1962); embracing environmental awareness (1960s); becoming part of the U.S. Department of Transportation (1967); withdrawing controversial interstate segments in return for funds for other purposes, including rail rapid transit (1973); and establishing a framework for a post-interstate program (1991).

Representative Walter P. Brownlow introduced a Federal-aid highway bill in Congress in 1902. He told a reporter that if people understood that the Federal Government could help build good roads, "you will find that Congress and the Constitution will not be against but for it." Like many innovations, his proposal was ahead of its time and went nowhere.

Filling in the Blanks

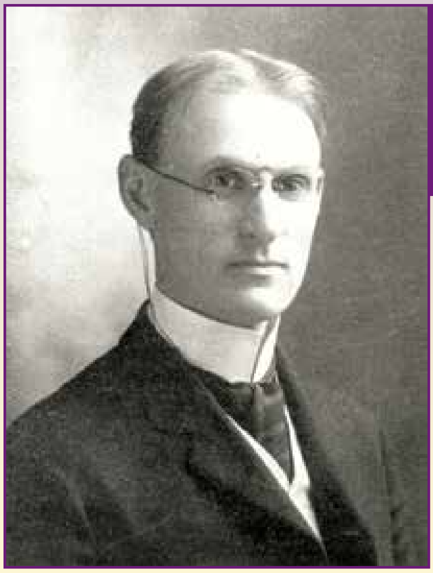
In the 21st century, motorists travel the country in air-conditioned cars with state-of-the-art sound systems, DVD players to amuse the kids in the back, USB ports to power the ubiquitous devices, safety rest areas for travelers' comfort, and service stations just beyond almost every interchange ramp.

One hundred years ago, long-distance travel did not involve fighting over what music would provide the soundtrack for the journey. And the roadside infrastructure to support long-distance travel appeared only gradually.

The extent of the blankness of the country's roads is reflected in how road guides of the day advised motorists to prepare for their trips. In the 1910s and 1920s, the guides advised motorists to take food, a tent, extra gallons of gasoline, spare tires and tire-patching materials, a gun or rifle, and a block-and-tackle to extricate trapped vehicles from the inevitable mud. Guides advised motorists not to wear new shoes and to consider their interstate travels "something of a sporting proposition." Motorists, in short, were on their own.

Necessity may be the mother of invention, but as any parent knows, aggravation can inspire desperate solutions. Interstate motorists camped on the roadside since they had no choice between towns. The roadside was, to put it politely, their restroom—over there behind that tree, bush, rock, or hill. When enough farmers objected to these intrusions, communities created motorist campsites. Gradually, communities began competing for motorists by introducing amenities such as water, showers, restrooms, and food.

As traffic increased, entrepreneurs installed cabins by the road. Owners competed for business by building better cabins with more facilities. The cabins became motels, a term coined in 1925 as an abbreviation



Maurice O. Eldridge, assistant director of the Office of Road Inquiry in 1903, advocated for the innovative idea of a Federal-aid highway program before its time.

for motor hotel. The individually owned motels, well known to motorists of the 1920s through the 1950s, were replaced in the interstate era by chain motels providing identical facilities from sea to shining sea and border to border.

Barriers

The idea of gradual or continuous innovation applies to many features of U.S. roadways.

At slow speeds, for example, going over a cliff or running into a tree or rock embankment takes extraordinary if not alcohol-induced inattention, uncommon lack of skill, and/or amazingly bad luck. High-speed vehicles made it much easier to run off the road.

Officials searching for ways to keep vehicles on the pavement tried alternatives that early on included wire rope cables linking wood or concrete posts. The number of cables increased, and the cable became stronger, but in 1925, a tension plate replaced the cables. Many innovations later, guardrails had become enabling a common feature of the roadside.

Several States began experimenting with concrete barriers in the 1940s to handle out-of-control trucks that plunged through guardrails and to reduce the cost of replacing guardrails in high-crash locations. In the 1950s, the New Jersey State Highway Department began using a concrete barrier developed by the Stevens Institute of Technology that functioned as more than a simple barrier. The sloped lower part of the barrier reduced damage by enabling vehicle tires to ride up on the sloped part to dissipate momentum and friction. The driver could regain control of the vehicle more easily and with less damage than might have been the case otherwise.

Although the New Jersey safety-shaped concrete barrier was invented for permanent use in narrow medians, "Jersey barrier" segments are also portable. They are used widely on either side of roads, in work zones, and around any type of construction, including many nontransportation settings such as around building sites and as security barriers.

You probably have noticed yellow barrels arranged bowling-pin style between a highway lane and an exit. They are impact attenuators filled with sand to disperse the energy of impacts in an explosion of sand to reduce damage to vehicles and occupants. The most common type, which was invented by race car driver John Fitch, began appearing on the Nation's roads in the 1960s. Aside from their value in saving lives and reducing injuries, the barrels have proven themselves to be a dramatic special effect, when filled with water, for crashes in movies and television shows.

The Computer Revolution

Innovation sometimes involves adapting ideas from another field for the work at hand. The computer is an example.

Data are at the heart of highway construction. Highway engineers such as Logan Page and Thomas H. MacDonald (who together headed the Federal road agency from 1905 to 1953), believed that data would enable them to make nonpartisan, scientific judgments, but processing the data was a complex challenge. For example, as mentioned earlier, the U.S. Office of Public Road Inquiry conducted the first national road inventory in 1904. The agency had to tabulate information from more than 60,000 communications with State, county, and township officials, a task that delayed publication until 1907.

The development of high-speed computers during World War II resulted in a breakthrough in data processing. By 1957, BPR's annual

Innovations often consist of a series of moves that improve upon past innovations. For example, this wire rope cable barrier on precast reinforced concrete posts was a common sight on many New England roads in the 1930s and 1940s. They were effective only up to a point. According to a U.S. Bureau of Public Roads report from 1936, "precast reinforced concrete posts are brittle and likely to crack under heavy impacts."

Highway officials quickly adopted the card-sorter machine (as shown in this 1961 image from BPR's Data Processing Branch) to meet transportation needs.

report began chronicling computer use: "An important activity in the past few years has been the development of applications for electronic computers as a means of expediting highway engineering operations and increasing highway engineering productivity."

The agency was working with the State highway agencies to compile "a library of electronic computer 'programs' for the solution of highway engineering problems." The concept was so new that the agency felt it needed to explain what a "program" was, namely "a detailed set of instructions regarding the feeding of data into the computer, and the sequences of operations to be performed by the machine, in order to obtain the desired solution to a specific problem."

The library of programs was to be shared with any State highway department or other cooperating agency. Already, 35 State highway agencies had decided to use electronic computers.

E. H. "Ted" Holmes, BPR's top urban planner until his retirement in 1971, recalled the computer breakthrough in the 1940s and early 1950s as BPR worked with State and local officials to determine where urban interstate highways should be built. The bureau had extensive data based on innovative polling techniques developed on a sampling basis with the Bureau of the Census. However, BPR had little ability to understand the relationship among travel desires, land use, and other social and economic factors.

Holmes wrote: "It was not until the high speed computer became available, and perhaps the almost simultaneous introduction into the field of highway planning of the sociologist, the geographer, the economist, and the city planner, that a real breakthrough in establishing these relations was achieved."

Initially, BPR used computers owned by others, including the Univac I at the Bureau of the Census and the IBM 705 owned by the DuPont Company in Wilmington, DE. But BPR soon began purchasing its own computers. In March 1961, for example, BPR installed a medium-scale computer with four magnetic tape units and 8,000 characters of memory in its headquarters, replacing a medium-size digital computer, compatible with punch cards, installed in 1958.

In June 1968, FHWA installed a Calcomp line plotter that could read a magnetic tape produced on a computer, interpret the data and its format, and draw the desired plan with up to four colored inks or ballpoint pens on regular drawing paper. The plotter tabletop was so large that it did not fit in the building's freight elevator or stairwell and had to be hoisted by crane through a window removed on the 7th floor.

Gradually, computers transformed how highway officials did business. A personal computer (PC) could be found on virtually every employee's desk. Slide rules, which once hung from the belt of every highway engineer, disappeared. Computer-aided designs for highways and bridges replaced drafting boards. Modeling became easier for traffic projections, noise impacts, conformity with clean air requirements, and many other purposes. Emails allowed instant communication. Management systems, initially for pavements and then bridges, enabled officials to synthesize large amounts of data before setting priorities for project selection. Electronic toll collection gave renewed importance to innovative financing techniques such as tolling and value pricing. Gradually, the computer combined with satellite tracking for such innovations as intelligent transportation systems and geographic information systems that have altered many aspects of transportation, including highway safety and trucking.

Meanwhile, secretaries, stenographers, and the "typing pool," innovations from a distant past that a few oldtimers remember, were disappearing. The computer shifted some clerical functions to the professional staff, many of whom miraculously discovered that they could type as soon as a keyboard with a PC attached to it arrived on their desks. Steno pads and shorthand, Dictaphones, and carbon paper disappeared along with the slide rules.

(To young people reading this article, if you don't know what a slide rule, carbon paper, or typewriter is, don't panic. You'll never need to know.)

From Innovation To Humdrum

On any street, the most commonplace objects were once innovative. Signs, traffic lights, medians, street lighting, overhead wires, pavement markings, the pavements themselves, WALK and DON'T WALK signs, street parking regulations, parking meters, and parking tickets. Someone at some time had each of these ideas and helped make them so universal that their creators' names are mostly forgotten. Even the fact they didn't exist at one time has been lost to time.

At the start of the 18th century, no one knew the steamship would

Innovations Gone Awry

It is likely that no one has ever calculated the ratio of good to bad innovations, but the U.S. road network has experienced its fair share of the latter. Here are a few that most engineers would rather forget:

Steel track roads. General Roy Stone and Martin Dodge promoted the idea of placing two narrow steel tracks in the road to provide solid support for vehicles. The agency built several experimental sections of steel track roads, but they proved impractical, in part because of the cost of the steel.

Three-lane highways. With a center lane for passing, this 1930s design concept was intended to enable motorists to pass on the narrow roads of the day. As impatient motorists passed slower moving vehicles in both directions at the same time, this innovation became known as "suicide" lanes.

Transcontinental superhighways. During the 1920s and 1930s, many visionaries imagined a single toll superhighway across the continent, with multiple lanes for different types of traffic, access control, grade-separated intersections, concession areas, and room for airports and utilities. T. E. Steiner, a businessman from Wooster, OH, was one of the many well-known advocates of this idea. He formed the Transcontinental Streamlined Super-Highway Corporation and promoted his plan throughout the country, including in testimony to Congress, promising that the network could be built from tolls and fees without Federal funds. These ideas generated public interest but went nowhere as the Bureau of Public Roads began promoting an interregional highway system in the late 1930s, forerunner to the interstate system.

Building through parks. To minimize disruption to homes and businesses, why not build freeways through urban parks? Just one problem: people loved their parks. Battles in Baltimore, MD; Memphis, TN; San Antonio, TX; and everywhere else roadbuilders tried this innovative solution, resulted in frustration and, mostly, parks without freeways in them.

The experimental steel track shown here was installed at the Trans-Mississippi and International Exposition in Omaha, NE, in 1898, to test its effectiveness as a solution to the alternatively muddy or dusty earth roads of those days. Here, Martin Dodge of the Office of Road Inquiry was seated in an electric car (left in the front seat in top hat). The cost of steel was one of the main reasons this idea did not catch on. Note that the steering wheel—an innovation itself—was not yet in common use.

be invented and dominate long-distance transportation by water. At the start of the 19th century, no one knew the railroad would be invented and do the same for surface transportation. At the start of the 20th century, no one knew that motor vehicles and the airplane would become the dominant modes.

And today, fairly early in the 21st century, no one knows whether some other transportation innovation is just around the corner to dominate the rest of the century—perhaps teleportation (preferably as in "Star Trek's" "Beam me up, Scotty," rather than as in "The Fly" movies where people emerge with fly parts). Or driverless cars, drones for small shipments, pavements made of solar panels that generate energy while carrying traffic, magnetic levitation trains (all safe predictions since they exist in varying degrees of development) or, a personal favorite, jet packs. Maybe everyone will have interactive earbuds that enable us to go to work, sightsee, visit friends and family, shop, go to school, and communicate with anyone—all without leaving the comfort of home. Perhaps Elon Musk's well-publicized high-speed "Hyperloop" network of pneumatic tubes (an innovation that people have been trying to adapt for transportation for a century and a half) will surprise everyone by actually working.

Who knows?

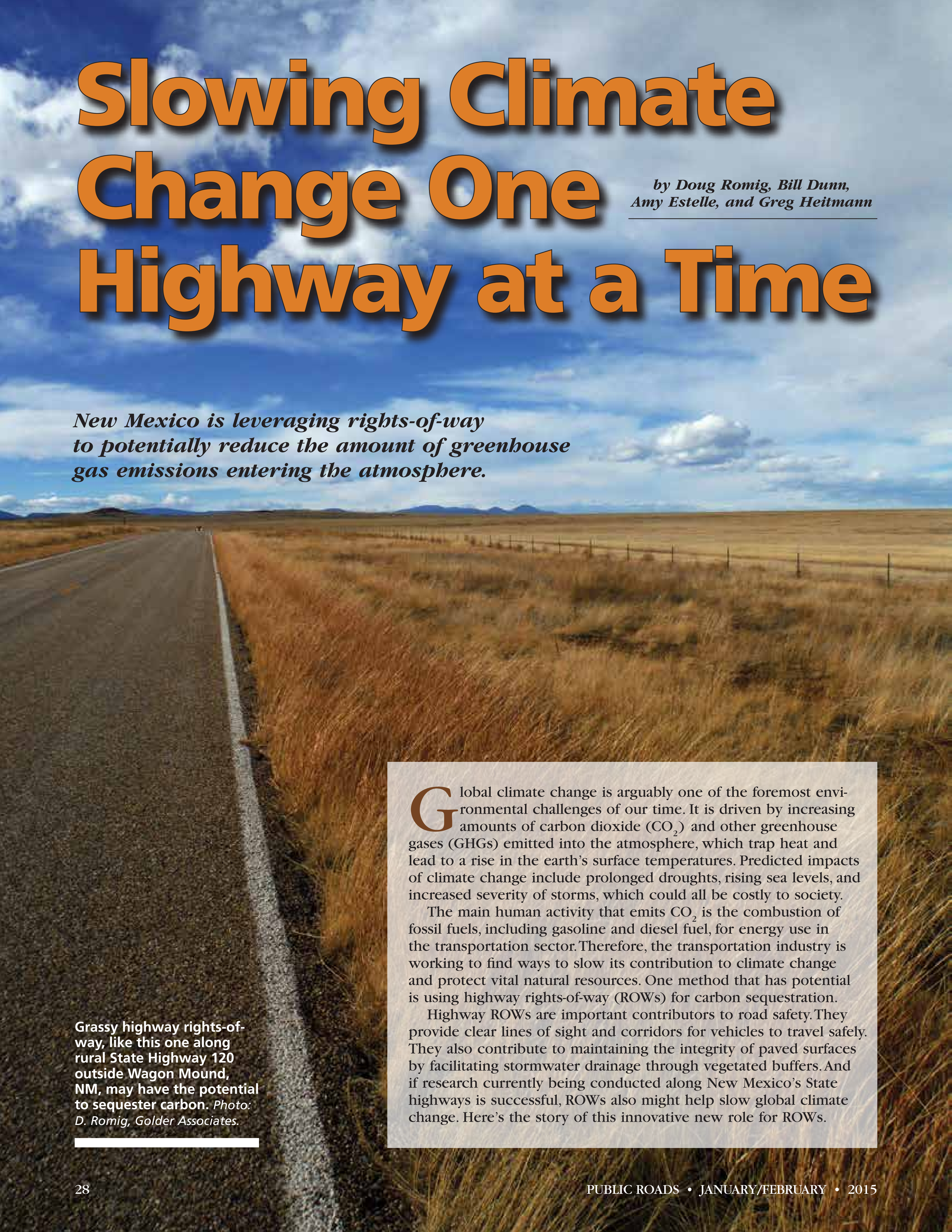
It is safe to say that transportation is an ever-evolving means of satisfying the age-old need for rapid movement of people, goods, and ideas. Each era builds the most innovative transportation network it is able to create with the brainpower and tools at hand—be it foot power; chariots on the ancient Roman road network; sailing ships with men pulling oars; horses, mules, camels, and elephants; covered wagon trains; railroads, bicycles, and motor vehicles; even the World Wide Web—and in each case, future generations wondered how the people of earlier times survived with such primitive means. In the same way, today's population wonders how people survived crossing the continent in prairie schooners pulled by ox teams or crank-started their Model Ts.

The current transportation network is the product of thousands of innovative steps, leaps, and tiptoes forward. Many think of it as the best transportation system in the world, the peak of transportation progress through the millenia, or at least a serviceable system if you aren't a member of the American Society of Civil Engineers (whose annual infrastructure report card in 2013 gave a C+ for bridges and a D for roads). Regardless, when that as-yet-unborn genius shows up to solve all of the Nation's transportation problems, his or her innovations eventually will seem as primitive to observers in the 22nd century as does the chariot to us.

Someday, surely, the little girl of the future will shyly ask, "Nana, did you ever ride in a car?"

Richard F. Weingroff is the information liaison specialist in FHWA's Office of Infrastructure. He also oversees the office's "Highway History" Web site.

For more information on the history of FHWA and transportation, see www.fhwa.dot.gov/infrastructure/history.cfm.



Slowing Climate Change One Highway at a Time

by Doug Romig, Bill Dunn, Amy Estelle, and Greg Heitmann

New Mexico is leveraging rights-of-way to potentially reduce the amount of greenhouse gas emissions entering the atmosphere.

Grassy highway rights-of-way, like this one along rural State Highway 120 outside Wagon Mound, NM, may have the potential to sequester carbon. *Photo: D. Romig, Golder Associates.*

Global climate change is arguably one of the foremost environmental challenges of our time. It is driven by increasing amounts of carbon dioxide (CO_2) and other greenhouse gases (GHGs) emitted into the atmosphere, which trap heat and lead to a rise in the earth's surface temperatures. Predicted impacts of climate change include prolonged droughts, rising sea levels, and increased severity of storms, which could all be costly to society.

The main human activity that emits CO_2 is the combustion of fossil fuels, including gasoline and diesel fuel, for energy use in the transportation sector. Therefore, the transportation industry is working to find ways to slow its contribution to climate change and protect vital natural resources. One method that has potential is using highway rights-of-way (ROWs) for carbon sequestration.

Highway ROWs are important contributors to road safety. They provide clear lines of sight and corridors for vehicles to travel safely. They also contribute to maintaining the integrity of paved surfaces by facilitating stormwater drainage through vegetated buffers. And if research currently being conducted along New Mexico's State highways is successful, ROWs also might help slow global climate change. Here's the story of this innovative new role for ROWs.

The Science of Carbon Sequestration

Solving the problem of global climate change is relatively straightforward—at least scientifically: reduce the amount of carbon emitted into the atmosphere and increase the amount removed. The process of removing CO_2 from the atmosphere is called carbon sequestration. Both the land and the ocean naturally sequester atmospheric carbon and are major reservoirs of carbon. Collectively they absorb approximately half of the carbon emissions produced by humans each year while the other half enters the atmosphere, causing increased CO_2 concentrations that contribute to climate change.

One way to absorb carbon from the atmosphere naturally is through photosynthesis, the process whereby plants capture CO_2 using energy from sunlight, and incorporate carbon into their roots, stems, trunks, and leaves. Ultimately, the plant dies and much of the carbon stored in its tissues is returned to the atmosphere through decomposition. Some of the plant carbon is consumed by animals (such as termites, earthworms, and rabbits) and microorganisms (such as bacteria, protozoa, and fungi) inhabiting the soil and they then transform it into soil organic matter.

Soil organic matter, otherwise known as humus, is the well-decomposed residues of plants and soil animals. It exists as large, complex carbon compounds that resist additional degradation. Soil carbon also exists, to a lesser degree, as inorganic carbonate minerals like calcite and gypsum. Soils are the largest land-based reservoir for carbon, accounting for nearly 80 percent of the carbon found in terrestrial ecosystems. In fact, an estimated 2,500 gigatons of carbon are currently stored in soils. That is more than three times the amount in the atmosphere, and about 100 times the amount of carbon produced by human activities each year.

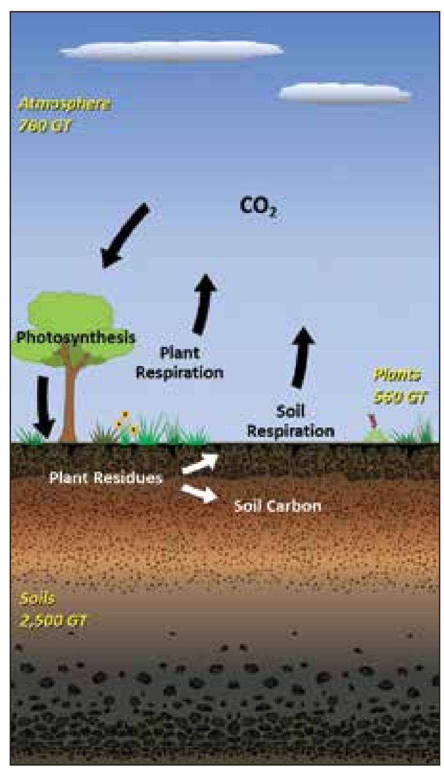
However, the rate at which plants transfer carbon to the soil generally is slow and a function of climate (temperature and precipitation). Soil carbon tends to accumulate faster in cooler, wetter climates simply because plants grow faster and the rate of decomposition is slower. To increase the amount of carbon sequestered by soils, changes in land management are necessary.

FHWA's Pilot Project

Beginning in 2008, the Federal Highway Administration's (FHWA) Office of Planning, Environment, and Realty and the Volpe National Transportation Center conducted a Carbon Sequestration Pilot Project. The project sought to "assess whether a roadside carbon sequestration effort through modified maintenance and management practices is appropriate and feasible for State departments of transportation . . . when balanced against ecological and economic uncertainties."

The FHWA project team estimated the amount of carbon that could be stored using native vegetation management on lands within the National Highway System. The team also considered the potential revenue that could be generated through the sale of carbon credits in a cap-and-trade market (a market-based approach that provides economic incentives for achieving reductions in GHG emissions) if normal vegetation management operations were modified to facilitate carbon sequestration in ROW soils and vegetation.

FHWA determined that more than 5 million acres (2 million hectares) of ROW are managed along the 163,000 miles (262,000 kilometers) of paved and unpaved roadways nationwide. The soils and vegetation on these lands currently store an estimated 100 million tons (91 million metric tons, MT) of carbon and sequester carbon at an estimated rate of 4 million tons (3.6 million MT) per year (1.17 tons per acre per year, or 2.62 MT per hectare per year). While carbon storage occurs naturally as part of the carbon cycle, ROW management practices have the potential to incrementally increase or accelerate carbon sequestration.



D. Romig, Golder Associates

Carbon cycles among the atmosphere, plants, and soils through the processes of photosynthesis, respiration, and decomposition. Worldwide, soils store 2,500 gigatons of carbon or 80 percent of the carbon stored in terrestrial ecosystems. Improving the soil's ability to sequester carbon may help slow global climate change.

The project team also estimated that the ROW on the National Highway System could potentially sequester up to seven times more carbon than it currently stores (between 468 and 750 million tons, or 425 and 680 million MT) through a combination of natural absorption and land management practices.

For more information on FHWA's Carbon Sequestration Pilot Project, visit www.fhwa.dot.gov/environment/climate_change/mitigation/publications_and_tools/carbon_sequestration.

Carbon Trading

Carbon trading markets, otherwise known as carbon registries, began on a country-by-country basis as early as 2003. Then in 2005, the Kyoto Protocol, a treaty in which industrialized countries agreed to reduce their collective emissions of GHGs, went into effect. European companies that emit GHGs are mandated to participate in carbon markets, but participation by U.S. companies in the Nation's carbon market remains voluntary.

Each registry establishes its own rules regarding carbon trading. In order to secure a tradable carbon credit, a carbon registry establishes a rigorous protocol to confirm that a particular activity provides a real,

B. Dunn, Big Picture Conservation

This team member is taking a soil sample at a ROW site in New Mexico.

additional, and verifiable reduction in atmospheric carbon. For example, protocols related to land uses, such as grazing and forestry, prescribe land management activities and GHG monitoring strategies that protect or restore lands and preserve or increase the amount of carbon sequestered in soil and vegetation. The registry assigns a value to the protocol based on how much it offsets GHG emissions relative to a "business as usual" baseline.

However, no carbon registry currently offers a protocol for generating carbon credits for ROW vegetation management. New Mexico's research will support development of such a protocol.

Managing ROW Vegetation

In 2011, the New Mexico Department of Transportation (NMDOT) began the first of a two-phase research study building on the results of FHWA's pilot project. The study's goal is to evaluate the potential to increase soil carbon sequestration and storage by managing ROW vegetation.

FHWA selected NMDOT for the study because the State has many miles of rural roads and thus many acres of ROW to manage. It also has diverse forests and grasslands that have the potential to sequester soil carbon. In addition, New Mexico was, at the time of selection, a member of a voluntary emissions trading program to meet statewide carbon reduction goals.

"New Mexico has a history of solving problems," says J. Don Martinez, the division administrator of the FHWA New Mexico Division Office. "[And] within New Mexico, we have numerous and diverse climate zones that could potentially translate across many regions of the country."

Rick Wessel, an anthropologist and archeologist with the Environmental Design Bureau of NMDOT, was the agency's advocate. "We saw the potential to offset rising maintenance costs and shrinking operational budgets with revenue from vegetation management that also mitigated climate change," he says. "It was a win-win opportunity. We also thought the project could assist New Mexico in meeting its emissions reduction goals. . . ."

In the first phase of the project, the goals were to determine the number of acres available for carbon sequestration, the amount of soil carbon currently in ROW soils, the environmental characteristics that affect carbon sequestration and soil carbon in these systems, and which vegetation management practices may lead to an increase in soil carbon.

What Is Out There Now?

So how do researchers go about estimating the amount of carbon in soils along approximately 4,780 miles (7,700 kilometers) of State highways that crisscross the fifth largest State in the country? From a scientific point of view, the assessment of soil carbon must contend with multiple levels of natural variability, including different soils and plant communities, varied precipitation and temperature regimes, and elevations between 2,500 and 13,000 feet (762 and 3,962 meters). Furthermore, because the soils in a ROW are manipulated during road construction, they may not resemble the native soils adjacent to the road.

To account for this variability, the researchers measured soil and vegetation at randomly selected sites in three environments: (1) high mountains with pine and fir forests; (2) lower mountains and foothills with shrub and woodland species; and (3) prairies dominated by short, sod-forming grasses. To account for the variability within ROWs, the research team developed a conceptual site model with four zones, each with a unique history of disturbance, management, local topography, and potential soil and vegetation characteristics. The zones are: (1) managed zone, adjacent to the road and subject to frequent maintenance activities and runoff from the road; (2) inflection zone, the swale where stormwater accumulates and drains; (3) transition zone, where the soils and native plant community were initially disturbed during road construction, but have returned to natural vegetation; and (4) natural zone, areas within the ROW not disturbed by road construction and in relatively pristine condition.

For two reasons, the project focused on areas in the State that receive at least 14 inches (35 centimeters) of precipitation annually. First, research has shown that, especially during periods of drought, more arid soils become net emission sources of CO_2 rather than carbon sinks (a reservoir for storing carbon). Second, aridic soils are naturally low in soil carbon and have slow sequestration rates, which make it difficult to measure changes in soil carbon over time. In fact, many carbon registries do not offer emission offsets from drier regions that have limited capacity to sequester soil carbon.

The research team collected more than 850 soil and 350 vegetation samples from 117 sites across New Mexico during October and November 2011. With soil samples from each ROW zone, researchers measured key characteristics such as total soil carbon, nitrogen, and texture. They visually assessed the vegetation by estimating the cover of grass, flowering plants, dead plant material, rock, and bare ground in sampling frames centrally placed in each ROW zone. Lastly, they collected all plant material (live and dead) from selected frames and weighed it to determine the aboveground biomass.

Researchers also measured the ROW width at each sample site. The data showed an average width of approximately 50 feet (15 meters) on each side of the paved roadway from the edge of the pavement to a property boundary, usually a fenceline. The NMDOT ROWs encompass 55,730 acres (22,557 hectares) of prairies, shrublands, and forests, equivalent to the land area of a large western cattle ranch.

From this dataset, the research team estimated that New Mexico State highway ROWs have a total of nearly 1.1 million tons (1 million MT) of soil carbon or 19 tons of soil carbon per acre (42 MT per hectare). As expected for New Mexico's semiarid climate, this amount of soil carbon is relatively low compared to other ecosystems such as temperate grasslands (116 tons per acre, 259 MT per hectare) or temperate forests (47 tons per acre, 106 MT per hectare). Researchers measured the highest carbon density at high elevation forested sites (25 tons per acre, 57 MT per hectare).

However, because most New Mexico highways are located in shortgrass prairies in the eastern part of the State, the prairie biome accounted for 65 percent of the total soil carbon in State ROWs. The highest densities of soil carbon occurred in the managed zones of both high elevation and prairie grassland sites where vegetation production benefits from water running off the pavement. Natural zones of forested sites at high elevations also had high soil carbon, due in part to increased amounts of snow and rain.

Driving Carbon Into New Mexico Soils

Using the data collected, researchers developed statistical models to search for environmental parameters associated with differences in soil carbon. For New Mexico, the models identified as the most important factors related to soil carbon were annual precipitation, grass production, dead plant material or litter, and clay content. The models also identified nitrogen levels in the soil to be directly related to the amount of carbon.

These findings were on par with current knowledge about the transfer of carbon from the atmosphere to the soil in southwestern plant communities. Specifically, warm season grasses, such as blue grama, flourish during the summer monsoonal rains that fall from July through September in New Mexico. During the growing season, blue grama grasses capture atmospheric carbon and store it in their fine roots as carbohydrates, which provide energy to keep the plant alive during the dormant season. A third of the grass roots die in the process, and these dead root tissues are transformed into organic matter by soil insects, bacteria, and fungi. Soils with higher nitrogen content also tend to produce more grass when sufficient soil moisture is available. In addition, clay content enhances the ability of soil to hold water for plants to utilize during the growing season.

The models also provided a means to predict how vegetation management might increase soil carbon. In particular, the models suggested that a small increase in grass production in the managed zone could result in a fairly substantial increase in soil carbon.

The next step in the research project was to determine how to employ the findings to increase grass growth, and in turn, soil carbon.

J. Schoellkopf, NMDOT

Raising the height of mowers like these has the potential to increase carbon sequestration.

Land Management To Increase Soil Carbon

Researchers investigated several treatments for land management to determine if they could potentially lead to an increase in grass productivity. Three showed the most promise: increasing mowing heights, seeding legumes (members of the pea plant family) to fix soil nitrogen in established ROW grasslands, and soil imprinting. Most important, NMDOT could implement these treatments on a large scale without interfering with required highway maintenance activities.

The standard mowing height in New Mexico is approximately 6 inches (15 centimeters), which generally removes most of the live tissue of grasses. If the mowing occurs during the growing season, grasses suddenly have significantly less leaf area for photosynthesis. In response, the plants divert the energy they capture into replacing leaf tissue instead of storing carbon in their roots. In some instances, grasses may even draw reserves from their roots to grow new leaves, thus decreasing the overall amount of plant carbon that could become organic matter. By raising the mower height to leave more leaf tissue, the rate of photosynthesis does not significantly decrease, and carbohydrates continue to be sent to the roots, which eventually leads to additional carbon sequestration.

Legumes have a symbiotic relationship with certain bacteria in their roots that enables them to convert atmospheric nitrogen into a form that is usable by plants. Increases in soil nitrogen can stimulate plant growth and increase root production, thereby potentially leading to an increase in soil carbon.

Soil imprinters are machines that mechanically create an array of offset indentations or divots approximately 4 inches (10 centimeters) deep on the soil surface. The uneven soil surface captures water and enables it to infiltrate the soil rather than run off, leading to an increase in the amount of water available to plants. The divots also may capture surface litter and potentially increase soil fertility. The combined increase in soil moisture and nutrients could, again, lead to more plant growth and higher rates of carbon sequestration.

D. Romig, Golder Associates

E. Marx, easterncoloradowildflowers.com

Interseeding native legumes, like the white prairie clover (right) being seeded by this machine (above), can increase available soil nitrogen.

Testing and Beyond

In the summer of 2013, NMDOT began the second phase of the project, testing the three treatments at eight sites in the State. The sites represent the ranges of precipitation and soil carbon found across New Mexico.

Over the next 2 years, the research team will measure soil carbon at the beginning and end of the test period; aboveground productivity of ROW vegetation; and the exchange in carbon among the atmosphere, vegetation, and soil using a state-of-the-art flux chamber. The equipment measures the rate of CO_2 flow in and out of the soil, soil moisture, and temperature. Together, these data, and the ecosystem models built from them, should provide a clearer picture of how ROWs can become reservoirs to store atmospheric carbon.

All in all, NMDOT has made progress in addressing its research objectives. If the findings from the second phase indicate carbon storage in ROWs is worth pursuing, the next step will be to ensure that any revisions to policies for ROW vegetation management are aligned with the primary objective of NMDOT—to provide a safe, reliable, and efficient transportation system. To ensure that this balance is achieved, the research team includes field maintenance staff who can confirm that recommended changes in roadside management are both practical and achievable. In addition, revisions to ROW vegetation management to sequester carbon will have to be accomplished within NMDOT's budgetary constraints.

"There seems to be endless debate pertaining to climate change and a link to greenhouse gases—gases that include carbon dioxide," says FHWA's Martinez. "NMDOT and the New Mexico Division Office, in conjunction with FHWA [headquarters], made a decision to look for solutions, and through scientific research, assess the use of NMDOT rights-of-way as a potential storage area for carbon. Depending on our findings, we are hopeful to have protocols in place that scrub carbon from the air and trap it in the soils of highway rights-of-way. From there we would like to be able to share our research nationally and internationally and see if others can apply it."

D. Romig, Golder Associates

Another ROW vegetation management practice that could increase carbon sequestration is imprinting. Shown above is a machine that is imprinting the soil, which enables the soil to capture more water and nutrients.

Doug Romig is senior soil scientist with Golder Associates Inc. in Albuquerque, NM. He has extensive experience in land restoration and natural resource management throughout the southwestern United States. He holds B.S. degrees in soil science and range management from New Mexico State University and an M.S. in soil science from the University of Wisconsin-Madison.

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Amy Estelle, Ph.D., is the engineering coordinator for NMDOT's Research Bureau and project manager for the Carbon Sequestration Pilot Project. She holds a B.S. in microbiology, an M.S. in natural resource management and administration, and a Ph.D. in American studies with emphasis on environment, technology, and culture.

Greg Heitmann is an environmental engineer with FHWA's New Mexico Division Office. He holds a B.S. in electrical engineering from South Dakota State University and has 25 years of experience working in the transportation field.

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K. Muzikar, Golder Associates

This state-of-the-art flux chamber measures the exchange of CO_2 among the atmosphere, plants, and soil, which helps researchers understand the dynamics of CO_2 in the ROW ecosystem and evaluate the potential of these lands to sequester soil carbon.

The Secret to Making Federal Tax Dollars Work for Your State

by Clark Merrefield, Susan Smichenko, and Gerry Flood

To improve safety on local roads, Florida accesses FHWA funds more quickly and with lower administrative costs. Learn from the Sunshine State's award-winning approach.

As other States may well have discovered, Florida found that making simple safety improvements to local roads could take as long as 3 to 5 years. The Florida Department of Transportation (FDOT) believes that this is way too long when lives are at stake.

In response, FDOT's District 7, working closely with the Florida Division of the Federal Highway Administration (FHWA), developed a "design-build push button" contract that has reduced the time to deliver simple, low-cost safety improvement projects to roughly 1 year. Transportation agencies in Florida's District 7—which includes the Tampa metropolitan area (Hillsborough County) and four neighboring counties—now can access Federal funds more easily and roll out safety improvements on local roads more quickly.

Small transportation agencies, particularly during the recession of the late 2000s, were struggling to maintain existing infrastructure and had few resources to address safety needs. In addition, Florida statute limits the State's seven transportation district agencies from directly using State funds for improvements on non-State roads.

(Above) This illuminated sign at an intersection in Florida's District 7 was one of the improvements that resulted from the district's safety program for local roads. Improved sign visibility is particularly important for irregular traffic regulations, such as this one disallowing right turns. *Photo: FDOT District 7.*

To supplement their budgets, local agencies turned, in part, to funds set aside by FHWA for safety improvements. But the State's system for accessing Federal funds, called the Local Agency Program, incurs about $20,000 in administrative costs per request. For example, for a local agency to access $50,000 in Federal money, that agency would need to outlay $20,000 in upfront administrative expenses. With an unfavorable investment-to-payoff ratio, particularly for small projects, few agencies were accessing those funds.

Over approximately the past 8 years, District 7 has worked to streamline the process for obtaining FHWA safety funds by exchanging knowledge at an annual summit for its county and municipal agencies. In addition to the summits, District 7 created a layered structure that includes technical support and encourages the use of local agency force account agreements to construct safety projects.

These initiatives have led to a simple and effective process to access Federal funds for implementing safety improvements on District 7's local roads. The summits, technical support, force account agreements, and design-build push button contracts also have nurtured a collaborative environment for local and State transportation professionals. Moreover, these programs can serve as a model for other districts in Florida—and, for that matter, for other States.

Safety Summits Encourage Communication

A higher percentage of serious crashes happen on District 7's local roads than on the local roads in other Florida districts. In fact, more than 3,700 fatal and serious injury crashes take place in District 7 every year, and 52 percent of those crashes occur on local roads.

In 2010, District 7 formally stepped up its efforts to improve safety on county and municipal roads by holding its first Local Agency Safety Summit. Thirty transportation professionals from District 7's counties and municipalities attended the first summit.

At these annual meetings, transportation experts from Federal and State governments brief local agency partners on strategies to reduce crashes. Local staff members have the opportunity to discuss their most pressing safety concerns and present their own ideas for improving safety on local roads. Most important, the summits provide an opportunity for local and State transportation professionals to meet face to face and decide how to use the pool of available Federal money for making safety improvements on county and municipal roads.

Approximately 100 people from around the district attended the most recent safety summit, held in early March 2014. (The 2015 safety summit was held as this issue of PUBLIC ROADS went to press.) Participants included board members of metropolitan planning organizations, law enforcement representatives, and managers and directors of local agencies.

Law enforcement officials, transportation planners, and traffic researchers presented updates on safety initiatives in the Tampa area. The presenters summarized the lessons learned from public outreach on safety issues, and described pedestrian and bicycle safety improvements on specific corridors.

Federal experts briefed attendees on the outlook for the Highway Safety Improvement Program (HSIP) and other Federal funding programs. The Federal representatives and District 7 staff provided updates to the district's *Local Agency Safety Funding Guide for Off-System Roadways*—a how-to document that helps local agencies find funding for safety projects. Also, the Federal officials summarized local HSIP-funded projects that were completed over the previous year.

"I was very happy that elected officials took notice," says Peter Hsu, safety engineer with District 7. "The first year there were no attendees at the director level. The attendees that first year liked our ideas to improve safety, and we liked their enthusiasm, but they didn't have the authority to make the call. Right now, attendees are at a higher level, and we are seeing results. I spent a lot of effort pushing pedestrian and bike safety at these summits, and in the last 4 years we have seen changes in Tampa Bay." Hsu added that the knowledge shared at each year's safety summit helped spur those changes.

Increased attention from Florida's transportation decisionmakers has affected the amount of Federal funding directed toward safety on local roads. Before the summits, 10 to 20 percent of HSIP funding in Florida went to safety improvements on those roads. By 2013—the third year of the summits—40 percent of HSIP funding went to local projects.

In 2013, District 7 received $18 million in funding requests and allocated more than $7 million

At District 7's 2014 safety summit, Peter Hsu, safety engineer with the district, explains how to apply for FHWA funds.

FDOT District 7

FDOT District 7

Local transportation professionals from District 7 and around the State fill the room at Florida's March 2014 Local Agency Safety Summit.

toward safety improvements on local roads. On average, county and municipal agencies in the district now submit more than 50 applications for Federal funds each year, up tenfold from the year before the safety summits began.

"We have a strong working relationship with Tampa staff and with the Hillsborough County Sheriff's Office, as well as the people working with Mothers Against Drunk Driving and other outside organizations," says Bob Campbell, manager of traffic engineering, Hillsborough County Public Works. "We work together almost on a daily basis. I got a call this morning about a safety issue, and if I hadn't been to the safety summit, I wouldn't have had that contact."

Accessing Federal Funds: A Layered Approach

Creating a forum for local agencies to exchange ideas and make contacts with other public safety professionals was the critical first step in District 7's plan to improve safety. But without funding, that exchange of knowledge would never turn into action.

Because the administrative costs of Florida's Local Agency Program were prohibitively high for local agencies, Hsu and his team at District 7 developed what he calls a "layered approach" to help county and municipal agencies access FHWA funds, as part of the State Transportation Improvement Program. Each layer works within the existing State and Federal funding framework, and each layer may be employed individually or in concert, depending on the safety needs of the local agency. The idea behind the layered approach is to provide local agencies with the technical means to assess their needs and the financial flexibility to address them.

The First Layer

Under the first layer, District 7 uses HSIP funds to finance low-cost safety improvements on local roads with no additional funding outlay required from county and municipal agencies. They submit applications for HSIP funds via the District 7 Web site (www.d7safetysummit.org/hsip) through an informal solicitation.

Hsu and his team have an annual budget of $350,000 in Federal safety funding for simple improvements that can be installed quickly and do not require a formal contracting process. Examples include flashing beacons or chevron signs on particularly dangerous and curvy roads. Since 2006, District 7 has been able to allocate even more funds for systemic safety improvements, including $2 million for countdown pedestrian signals, $1.2 million for speed feedback signs at schools, and $1 million for school flashers, among other simple and effective safety improvements.

Signs and signal accessories are installed within the right-of-way area, so land acquisition and easements are not required. Local agencies are responsible for maintaining the equipment.

The FHWA Florida Division leadership strongly supports this first-layer initiative and quickly approves safety purchases that District 7 submits.

The Second Layer

Many county and municipal agencies in Florida are small. Although they may have the staff and budget to identify and perform basic road

FDOT District 7

(L-R): Sergeant George Edmiston, supervisor with the Largo Police Traffic Safety Unit, and Corporal Timothy Craig, supervisor with the Hillsborough County Sheriff's Office Traffic Unit, participate in the 2014 summit.

maintenance, they may lack the analytical expertise to determine precisely what safety improvements should be made and where. Without a data-driven approach to safety, local agencies do not have the facts to justify spending taxpayer dollars.

Within the second-layer approach, District 7 provides technical assistance. To improve data quality, the district centralized local crash databases, improved location data, and created a simple user interface for the centralized database. The district encouraged all five of its counties to submit data and use the new system. The most significant improvement was to establish relationships that encourage data sharing and cooperation.

"Hernando County, for instance, is a one-man show when it comes to road safety," Hsu says. "I have people in their office 2 days a week helping to crank up their analyses. Projects really rely on cost-benefit ratios."

Also falling under the second layer are monthly webinars held by District 7 to provide additional technical assistance. On the off-months between safety summits, the district's Local Agency Traffic Safety Academy hosts webinars to bring together local agencies, engineers, planners, and anyone else interested in traffic safety. The webinars connect them with experts on crash analysis, the permitting process as it relates to traffic safety, the basics of traffic signal operations, signing and pavement marking reflectivity, and numerous other safety management topics.

The Third Layer

The third layer comprises what District 7 calls its design-build push button contracts, one of the innovations under FHWA's Every Day Counts initiative. District 7 spearheaded a pilot program for a design-build push button contract in 2007. Essentially, it is a contract template that covers the project process from design to construction. Local agencies that use the design-build push button contract can implement safety projects in a fraction of the time needed for typical projects. Local agencies need only "push a button"—use the contract template—to get their safety projects off the ground, with assistance from District 7.

This view shows an example of centerline striping that was replaced by raised rumble strips. Safety improvements like these on local roads in District 7 were made possible through Federal funding accessed by using FDOT's layered approach.

FDOT District 7

Although this kind of contract provides local agencies with easier access to Federal funds, it is considered a project delivery method rather than a funding mechanism. The design-build push button contract potentially shaves years off of projects by preselecting and prequalifying contracting teams, and putting task work orders under an umbrella project where prices are already negotiated.

Once District 7 had ensured that Federal dollars for safety could be made available through design-build push button contracts, it held an informational meeting with industry consultants and contractors. After incorporating their input, the district executed its first contract in late 2009.

From 2009 to 2012, projects that used the design-build push button framework created 63 jobs and saved 25 more, and funded 55 projects ranging from $33,000 to $2.7 million. During this time, FDOT distributed $20.1 million in funds toward safety improvements using design-build push button contracts—which included $12.2 million in Federal funds, $6.1 million in State transportation safety funds, and $1.8 million from other State funds.

Federally funded projects covered more than 109 miles (175 kilometers) of roadway with inverted profile markings—which, like rumble strips, audibly alert drivers who are veering off roads—and wet weather audible striping to address lane departure crashes. Those projects also included pedestrian improvements, such as repainting crosswalks, for more than 510 intersections; added more than 54 miles (87 kilometers) of bicycle lanes; implemented 12 intersection improvement projects; added high-friction pavement for two interstate ramps; rebuilt signals for three locations; and implemented one intelligent transportation system project.

District 7 was able to complete numerous safety improvement projects because design-build push button contracts dramatically reduce the funding, design, and construction processes. Traditional projects may take more than 36 months from certification to completion, while design-build push button projects typically take only 13 months from design to completion.

FDOT District 7

Shown here is one of the binders that contains FDOT District 7's *Design-Build Push Button Contract* manual. The binder includes an instructional DVD in a pullout sleeve.

"It's almost like a key was turned, like a light was turned on," says Mike Frederick, transportation manager, St. Petersburg Transportation and Parking Management Department. "For years it was smoke and mirrors. We knew all this money was available, and we couldn't get our hands on it. Now, this is how it's done; it's standard operating procedure. In the past it was like everyone was working autonomously, and now we're all rolling in the same direction."

The Fourth Layer

The fourth layer for accessing Federal funds uses Florida's Local Agency Program procurement process for local agencies and municipalities to design and construct transportation projects using Federal funds. FDOT is responsible for sound stewardship of those Federal funds. Local agencies often find the Local Agency Program most useful for longer term, larger budget projects, such as median modifications, lighting projects, and infrastructure improvements to mitigate roadway departure crashes. Before a municipal or county agency enters the Local Agency Program, FDOT must verify that the local agency can undertake and satisfactorily complete the work. Federal funding might be rescinded if project milestones are not met.

Local agencies may prefer the Local Agency Program procurement process in some cases because it allows for more control over design and implementation. In addition, the agency retains more approval authority throughout the development phase than under the first three layers.

As discussed earlier under the second layer, District 7 provides technical assistance to local agencies. Under this fourth layer, District 7 also provides assistance toward achieving Local Agency Program certification, which is needed before the local agency can apply for funding. Also included is help with navigating the remainder of the approval process for the Local Agency Program.

The Fifth Layer

District 7 recently added a fifth layer to its framework for executing low-cost, Federal-aid safety projects on local roads. The fifth layer focuses on local force account agreements. District 7 uses this flexibility so that municipal work crews (local forces) can construct safety improvements, instead of requiring the usual competitive bidding processes for hiring outside contractors.

To use a local force account agreement, approval must be given to the local agency through a cost-effectiveness review, which ensures that labor, equipment, materials, and supplies are used efficiently

FDOT District 7

FDOT District 7

The upgraded pedestrian crosswalk shown in these before (above) and after (right) photos is another safety improvement completed in District 7.

to achieve the lowest overall cost. Force account agreements are cost effective for safety improvements that are relatively inexpensive and easy to build. FDOT reimburses agencies for wages related to work performed by local road crews on projects covered by local force account agreements.

"It's a new approach for us," says Frederick. "Previously, we'd have to go and identify the project and confirm the crash data ourselves and then usually hire an outside force to do the construction. But we can use city crews more cheaply and quickly."

Reducing Correctable Crashes

Correctable crashes are one safety issue that an agency can address relatively easily through simple infrastructure improvements. District 7 reviewed the before-and-after impacts on correctable crashes from five simple projects for infrastructure improvement. For example, inverted profile pavement markings installed on a stretch of SR–35 reduced the annual number of correctable crashes from 11.75 before construction to 3.33 after construction.

A new traffic signal on SR–582 reduced annual correctable crashes from 7 before construction to 1 after construction. And high-friction pavement installed on a ramp from I–275 to SR–60 reduced annual correctable crashes from 16.5 before construction to 3 after construction.

Preliminary statistics show that serious injuries and fatalities related to lane departure crashes are falling dramatically in District 7. From 2008–2010, there were 1,626 such serious injuries and fatalities, compared to 1,159 in 2011–2013, a 30-percent decrease in just 3 years.

Observable Safety Impacts

Although it is too soon for a holistic analysis of the safety impacts attributable to the annual summits and the layered approach for accessing Federal funds, several pieces of evidence indicate that these efforts are working, both to reduce crashes and to enhance relationships between local and State transportation professionals. Thirty-nine percent of the participants at the most recent safety summit completed a satisfaction survey and wrote that the knowledge and information they gained at the summit would definitely be useful in their work. Ninety-five percent gave a positive overall assessment of the summit, and respondents commented that the summit was "dynamic and fast paced" and a "very good format—short presentations were a key to success."

"The advantage is that now we have a success story in District 7," says Felix Delgado, former safety specialist with the FHWA Florida Division. "The goal is to compare crash trends among the seven districts in Florida. If we can say we are having positive results and fewer crashes, we can argue that this helped. It comes down to data analysis, but we're only in the fourth year of the annual safety summit."

Another noticeable impact is in the amount of money that District 7 receives from the State's pool of Federal transportation safety funds. Formerly, each of the State's seven districts would receive equal annual funding allocations. The system changed in 2012 to one in which FDOT allocates funds based on the feasibility of the projects proposed by the districts. Although allocation amounts are still roughly equal, in recent years, District 7 has received slightly higher allotments.

"District 7 gets extra funding because its local roads projects tend to be low cost with higher net present values," Delgado says. "And low-cost projects with high net present values indicate an efficient use of Federal funds."

A Model for the State

District 7 has reached out across the State to law enforcement and transportation professionals from other districts, encouraging them to attend the annual safety summits and to implement similar initiatives and funding frameworks

FDOT District 7

FDOT District 7

These before (above) and after (right) views show installed overhead signage, another example of a safety improvement on a local road in District 7.

FDOT District 7

Simple signage improvements, like this caution for right-turning vehicles to yield to pedestrians, help increase driver awareness and prevent fatalities and injuries on local roads in District 7.

in their own districts. In addition, District 7's program has attracted interest from other States.

"People from as far away as Miami come up to visit, to learn what's going on here," Hsu says. "Identifying safety issues is relatively easy, but working on local roads without a lot of information is very tough. We want to make sure that we account for the National Environmental Policy Act and other things we have no control over, while seeing projects through to completion as quickly as possible."

Award-Winning Thinking

A variety of industry groups have recognized District 7's use of design-build push button contracts. The district received a 2013 Best in Construction Award from the Florida Transportation Builders Association; a 2012 Prudential-Davis Productivity Eagle award, which recognizes a team or individual displaying exemplary performance for 5 years or longer; a 2011 Prudential-Davis Productivity Award, which recognizes innovative cost-saving strategies at the State level; and a 2010 John W. Barr Transportation Achievement Award from the Florida Institute of Transportation Engineers.

These awards showcase the success that District 7 has had in building collaboration between State and local partners, working with local agencies to access Federal funds, and substantially cutting down the years and dollars needed to complete safety improvements on local roads. Most important, in just a few years, District 7 has shown that even on shoestring budgets it is possible to fulfill its mission to "reduce the number of fatalities and serious injuries caused by traffic crashes."

Clark Merrefield is a writer and editor who works on a variety of communications materials at Volpe, The National Transportation Systems Center. He graduated with a master's degree in journalism from the City University of New York Graduate School of Journalism and a bachelor's degree from Cornell University.

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For more information, visit FHWA's Roadway Safety Noteworthy Practices Database at http://rspcb.safety.fhwa.dot.gov/noteworthy and see the Assessment of Local Road Safety Funding, Training, and Technical Assistance *(FHWA-SA-13-029) report at http://safety.fhwa.dot.gov/local_rural/training/fhwasa13029. Also visit FDOT District 7 at www.dot.state.fl.us/publicinformationoffice/moreDOT/districts/dist7.shtm. Contact Clark Merrefield at 617-494-3765 or clark.merrefield.ctr@dot.gov.*

Along the Road

Along the Road is the place to look for information about current and upcoming activities, developments, trends, and items of general interest to the highway community. This information comes from U.S. Department of Transportation (USDOT) sources unless otherwise indicated. Your suggestions and input are welcome. Let's meet along the road.

Management and Administration

President Obama Launches Transportation Investment Center

President Barack Obama recently announced the Build America Investment Initiative, a governmentwide effort to increase investments in infrastructure and economic growth. The initiative aims to engage State and local governments, as well as private sector investors, to encourage collaboration, expand the market for public-private partnerships, and get more out of existing Federal programs that provide financing options for qualified projects.

One part of the initiative is the Build America Transportation Investment Center, USDOT's new all-inclusive source for State and local governments, public and private developers, and investors seeking financing strategies for transportation infrastructure projects. The center's Web site at www.transportation.gov/buildamerica offers resources and tools for project sponsors exploring public-private partnerships. Visitors can learn more about transportation funding and financing, including grants, credit and loan programs, and bonds, and access helpful toolkits and training materials related to innovative financing techniques. The site also offers tools and information to expedite project delivery by fulfilling environmental review requirements, cutting through red tape, and achieving timely decisions, as well as information about Federal- and State-level policies and programs that enable private financing.

The President's initiative also formed the Build America Interagency Working Group, which Secretary of Transportation Anthony Foxx leads jointly with Secretary of the Treasury Jacob J. "Jack" Lew. The group works with State and local governments, project developers, investors, and others to address barriers to private investments and partnerships in infrastructure.

For more information, visit www.transportation.gov/buildamerica.

Secretary Foxx Awards Millions to Accelerate Innovative Projects

Secretary of Transportation Anthony Foxx recently announced more than $4 million in grants from the Federal Highway Administration (FHWA) designed to accelerate innovation in delivery of highway projects. The funds, which offset the cost of demonstration projects, will help to get roads and bridges repaired and built faster and more efficiently.

The recently announced funds are the first grants to be awarded under FHWA's Accelerated Innovation Deployment (AID) Demonstration program, which will ultimately invest $30 million to assist Federal, State, local, and tribal government agencies in hastening their use of these innovative methods. The AID Demonstration program builds on the success of the agency's ongoing Every Day Counts initiative, a partnership between FHWA and State and local transportation agencies to accelerate the deployment of innovative methods and shorten project delivery times.

The six AID Demonstration grants go to transportation agencies in Alabama (two projects), Iowa, Oklahoma, and Vermont, as well as the U.S. Forest Service. Projects include a slide-in bridge replacement, advanced transportation management and traveler information systems, and high-friction road surface treatments.

For more information about these grants and FHWA's AID Demonstration program, visit www.fhwa.dot.gov/accelerating/grants.

Technical News

Simulator Safely Tests Dangerous Driving Scenarios

When it comes to studying driver behavior, safety considerations preclude placing test drivers in dangerous situations to assess their reactions. Instead, to study how a driver might behave when crossing a railroad track in front of an approaching train or when traveling in a vehicle accelerating to 120 miles (193 kilometers) per hour, researchers rely on simulators. Simulation studies can provide important safety data that shape new technologies and Federal regulations.

Volpe

A woman operates Volpe's simulator, driving down a virtual urban highway displayed on five screens that offer a realistic experience.

Volpe, the National Transportation Systems Center in Massachusetts, recently acquired a new research driving simulator that features five 55-inch (140-centimeter) screens that wrap 180 degrees around users. The simulator provides a wide field of view that more closely emulates the real-world experience of driving than typical single-screen training simulators can. Owned by the Federal Railroad Administration and housed and operated by Volpe, the custom-built simulator enables researchers to create virtual scenarios that include freeways, country roads, and urban streets. The device can emulate the performance characteristics of a range of vehicle types in different weather and lighting conditions.

Currently, Volpe is using the driving simulator for an experiment for the National Highway Traffic Safety Administration (NHTSA) to examine how the driver-vehicle interface affects drivers' abilities to cope with unintended acceleration. Another project planned for the simulator is a study of motorist decisionmaking, including motivations and expectations, at highway-railroad grade crossings. Researchers hope to gain an understanding of why motorists collide with trains or risk being hit by them.

In the future, Volpe researchers plan to use the new driving simulator for autonomous vehicle testing and to gauge driver responses to warnings about approaching trains via dedicated short-range communication systems.

Volpe

NHTSA Unveils VIN Search Tool for Vehicle Recalls

Every year, manufacturers recall millions of vehicles in the United States due to safety defects or noncompliance with Federal safety standards. To help car buyers, owners, and renters know that their vehicles are safe and that any safety defects have been addressed, NHTSA launched a free online search tool that enables consumers to find out if their vehicles have been involved in a recall.

The new tool is available at www.safercar.gov/vinlookup and provides consumers with a quick and easy way to identify open recalls by entering their vehicle identification number (VIN). All major light vehicle and motorcycle brands are searchable.

Consumers can find their VIN by looking at the dashboard on the driver's side of the vehicle, or on the driver's side door where the door latches when it is closed. After entering the VIN into the field, results will appear if the consumer has an open recall on his or her vehicle, and if there are none, owners will see the message "No Open Recalls."

NHTSA is working with the National Automobile Dealers Association to help ensure that franchise dealerships across the United States become aware of and understand how to use the new search tool.

NHTSA

TxDOT Web Tool Helps Drivers Save Money, Reduce Emissions

The Texas Department of Transportation (TxDOT) recently launched a Web-based app to help consumers keep their vehicles road-ready while saving money on gas. Along with helpful hints for keeping vehicles operating efficiently, the Roadcents tool offers tips for reducing emissions that contribute to air pollution.

TxDOT

Driving a vehicle that needs maintenance can add more than $100 to a motorist's annual gas spending. Likewise, underinflated tires increase vehicle emissions and can add an extra $85 a year to fuel costs. Poor driving habits such as speeding and rapid starts and stops also can cost a driver as much as $850 a year in gas.

Roadcents is a Web-based interface for a mobile device or computer that gives drivers the tools to track vehicle maintenance and calculate how much they can save by changing their driving and vehicle maintenance habits. Drivers also can receive email alerts when their vehicles are scheduled for maintenance, find nearby auto repair facilities and gas stations, and get tips on what to do in case of a roadside breakdown or collision.

Since 2002, TxDOT's Drive Clean Across Texas campaign—now known as Drive Clean Texas—has urged drivers to take simple steps to keep their vehicles running properly and reduce emissions that affect the State's air quality. Roadcents is the campaign's latest initiative.

To use Roadcents, Texas consumers simply need to visit www.DriveCleanTexas.org, create an account, and enter their vehicle information. The Web site also offers additional ideas on reducing air pollution and saving money at the gas pump.

TxDOT

Public Information and Information Exchange

FHWA Releases Manual on Safety Treatments for Rural Roads

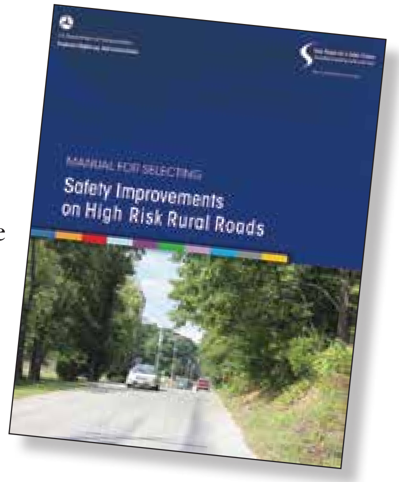
Transportation agencies across the United States use many treatments to improve safety on high risk rural roads. With the large number of safety treatments available, it can be challenging for practitioners to select the most effective treatment to implement with limited funds.

To address this challenge, FHWA recently released the *Manual for Selecting Safety Improvements on High Risk Rural Roads* (FHWA-SA-14-075). The manual enables users to quickly identify and compare cost-effective, low-cost, and proven infrastructure treatments to reduce crashes on high risk rural roads, including collectors and local roads.

Based on research into State, local, and tribal agencies' noteworthy practices, the manual is organized to assist in the selection of safety treatments that address 10 roadway feature types, such as horizontal curves and signalized and unsignalized intersections. For each roadway feature type, a treatment matrix outlines the most effective safety treatments and provides information on each treatment's safety benefits, initial and recurring maintenance costs, and benefit-cost ratio. The matrix may be used to help narrow the list of potential treatments by sorting through criteria specific to the practitioner's needs and available resources.

The manual also includes an overview of safety program management, potential funding sources, and funding processes, as well as decisionmaking tools for selecting appropriate safety treatments for given crash types and roadway characteristics.

Practitioners may find this manual particularly useful in developing strategic transportation safety plans. After selecting potential safety treatments, however, an agency should always use an engineering study to determine if the treatments would be ideal at a given location based on the site's characteristics, agency standards, local driving laws, and other factors.



The manual is available at http://safety.fhwa.dot.gov/hsip/hrrr/manual. For more information on high risk rural roads, visit http://safety.fhwa.dot.gov/hsip/hrrr.

NHTSA Study Shows Economic and Societal Impacts of Crashes

NHTSA released a study that underscores the high economic toll and societal impacts of motor vehicle crashes in the United States. According to the study, crashes resulted in an estimated $871 billion cost in terms of economic losses and societal harm in 2010. This includes $277 billion in economic costs and $594 billion in harm from the loss of life and the pain and decreased quality of life resulting from injuries.

In 2010, roadway crashes caused 32,999 fatalities and 3.9 million nonfatal injuries, as well as damage to 24 million vehicles. The study, *The Economic and Societal Impact of Motor Vehicle Crashes, 2010*, cites several major factors as contributing to costly roadway crashes that year, including drunk driving (accounting for 18 percent of the total economic loss), speeding (21 percent), and distracted driving (17 percent). Pedestrians and bicyclists (7 percent) and unbelted vehicle occupants (5 percent) were among the other contributing factors.

All levels of society—including the individual crash victims and their families, employers, and society at large—are affected by motor vehicle crashes in many ways. Factors contributing to the cost of the crashes include productivity losses, property damage, medical and rehabilitation costs, congestion costs, legal and court costs, emergency services, insurance administration costs, and the costs to employers. Overall, those not directly involved in crashes pay for nearly 75 percent of these costs, primarily through taxes and insurance premiums, as well as through congestion-related costs such as travel delay, excess fuel consumption, and increased environmental impacts. These costs, borne by society rather than the individuals involved in the crashes, totaled more than $200 billion.

NHTSA's purpose for presenting these costs in the report is to place in perspective the economic losses and societal harm that result from crashes, and to provide information to government officials and the private sector for use in structuring programs to reduce or prevent these losses.

For more information and to access the full report, visit www-nrd.nhtsa.dot.gov/Pubs/812013.pdf.

NHTSA

VDOT Research on Wildlife Aims to Increase Roadway Safety

The Virginia Department of Transportation (VDOT) is working to make roads safer—not just for motorists but also wildlife—by studying the travel patterns of animals. VDOT's research division, the Virginia Center for Transportation Innovation and Research, is conducting a 3-year study to identify strategic locations to reduce animal-vehicle collisions.

For the study, VDOT targeted a section of I–64 on Afton Mountain in Albemarle, Augusta, and Nelson counties because of the high number of wildlife-related crashes in those areas. When the study began in 2012, deer-vehicle collisions were the third most frequent type of crash in the region, accounting for up to 30 percent of all crashes. Recent numbers include 300 deer fatalities from 2012 to 2014 on I–64 along Afton Mountain, plus 10 black bear deaths in the same area in September and October 2013. The study will be completed in late 2015.

VDOT

A bear and her cubs pause beside a Virginia interstate. VDOT is conducting a study to determine wildlife patterns in order to reduce wildlife-vehicle collisions and increase safety.

A 2008 FHWA report to Congress, *Wildlife-Vehicle Collision Reduction Study* (FHWA-HRT-08-034), found that the most effective methods to reduce such crashes are fencing, either alone or used with wildlife crossings (overpasses or underpasses), and early-warning systems that can detect animals near the roadway and alert drivers.

VDOT published two other research studies in 2005 and 2010 that investigated the use of animal underpasses by wildlife throughout Virginia. They both concluded that if such structures are properly located and are the right size, deer, bears, and other animals will use them.

For more information, visit http://vtrc.virginiadot.org/PROJDetails.aspx?Id=519.

VDOT

Wyoming Raises Speed Limit to 80 Miles Per Hour on 488 Miles of Interstate

Motorists now can legally drive up to 80 miles per hour (mi/h) (129 kilometers per hour, km/h) on some sections of rural interstate highway in Wyoming. The State legislature agreed to raise the speed limit during its 2014 session. The Wyoming Department of Transportation (WYDOT) has updated the speed limit signs along three sections of I–25, totaling 268 miles (431 kilometers) in length, as well as on three sections of I–80 (116 miles, 187 kilometers) and two sections of I–90 (104 miles, 167 kilometers).

At the direction of the legislature, WYDOT conducted a study of the three rural interstate routes to determine where a speed limit of 80 mi/h (129 km/h) was appropriate. Factors considered in the study were roadway characteristics, including curves, grades, and width and proximity of interchanges. WYDOT also looked at traffic patterns, including current average speeds, traffic volumes, and the proportion of commercial trucks and passenger vehicles. Researchers also considered safety statistics, including crash rates and the relative severity of crashes in terms of the number of fatalities and serious injuries.

Rick Carpenter, WYDOT

WYDOT recently installed 80 mi/h speed limit signs, like this one posted along I–25 north of Cheyenne, WY, along 488 miles (785 kilometers) of rural highway.

WYDOT will continue to monitor the interstate sections with the increased speed limit and revisit the changes to determine whether adjustments in section lengths are warranted. The agency also is assessing two additional sections of I–80 and I–90 where a speed limit increase could be possible.

Wyoming joins Idaho, Texas, and Utah as States that have speed limits above 75 mi/h (120 km/h) on selected rural highways.

For more information, visit www.dot.state.wy.us/news/80-mph-speed-limit-in-effect-on-488-miles-of-interstates.

WYDOT

ODOT

Repair crews carefully install tension rods between support brackets on the James C. Nance bridge in Oklahoma. ODOT closed the bridge after it found significant cracking, but repaired and reopened the bridge in less than 5 months.

Oklahoma Bridge Reopening Reunites a Community

The Oklahoma towns of Purcell and Lexington, less than a mile (1.6 kilometers) apart on opposite sides of the South Canadian River, recently celebrated the reopening of the James C. Nance bridge that connects the two communities. The Oklahoma Department of Transportation (ODOT) closed the U.S. 77/SH–39 bridge to all traffic in January 2014 for emergency repairs. The closure of the bridge, which lasted for nearly 5 months, caused hardships for the people and businesses of both towns, including a detour through Norman, OK, that added 35 minutes to travel times.

ODOT closed the bridge after finding 11 cracks in areas of the bridge beams associated with welds made on an unusual type of manganese steel during a nearly completed project. Oklahoma Governor Mary Fallin declared a state of emergency to help ODOT expedite the repair project.

ODOT awarded a contract for emergency bridge repairs 2 weeks after the closure, and included unprecedented time-based financial incentives and disincentives to reopen the bridge as quickly as possible. Upon further inspections, the number of cracks grew to more than 100. The contractor repaired more than 1,000 weakened areas with brackets, tension rods, and specially fabricated support plates at a cost of more than $20 million from ODOT's contingency fund.

Despite the additional cracks found during the repair process, ODOT was able to reopen the bridge to passenger vehicles in less than 5 months, a process that normally would have taken a year. A restricted weight limit on trucks remained in place for 2 months while ODOT evaluated the performance of the repairs under car traffic. A weight limit of 36 tons (33 metric tons) remains in effect on the bridge.

The bridge was built in 1938 and carries about 10,000 vehicles a day. ODOT has expedited construction of a new bridge within the next 5 years.

ODOT

by Carrie Boris

e-NEPA Aims to Streamline Environmental Reviews

Transportation agencies at the Federal, State, and local levels are dedicated to balancing transportation planning and infrastructure needs with environmental protection. The National Environmental Policy Act of 1969 (NEPA) established regulations and processes for project planning and implementation to ensure that environmental impacts and sustainability are considered in transportation projects. However, producing the necessary documentation can be time and labor intensive and the multiagency collaboration often required by NEPA processes can be challenging and, at times, inefficient.

The Federal Highway Administration's (FHWA) Every Day Counts (EDC) initiative encourages mainstream adoption of innovations and processes to reduce project delivery times and improve safety. An innovation chosen for the third round of EDC seeks to improve the NEPA process and expedite project delivery with a realtime tool for electronic collaboration. The tool, known as e-NEPA, enables State departments of transportation to share documents, track comments, and schedule tasks with participating agencies, and perform concurrent reviews for their projects.

Improving Collaboration

Experience has shown that concurrent agency reviews and quality documentation significantly improve the efficiency and effectiveness of the NEPA decisionmaking process. e-NEPA is an online workspace and collaboration forum that helps agencies transition to an electronic review process, facilitating more effective interagency dialog in real time.

Although timely document sharing is an important part of e-NEPA, the tool is much more than a file transfer system. Developers designed e-NEPA to facilitate collaborative aspects of the transportation project development process, particularly for complex projects that require environmental assessments and environmental impact statements. Custom workflows enable project managers and planners to post project schedules; invite, collect, and share comments on documents; post due dates; and display project statuses.

"e-NEPA users can exchange documents, comments, and information in real time to allow concurrent reviews of documents and decisionmaking," says Bill Ostrum of FHWA's Office of Project Development and Environmental Review. "The tool also tracks and organizes the decisionmaking process, enabling project managers to dedicate their time where it's most needed, ensuring an effective and efficient review process."

e-NEPA helps build the project record, a critical part of the decisionmaking process. The record includes decision notes, public comment letters, minutes of meetings, records of phone and email communications, and documentation of public involvement efforts, as well as drafts and circulated copies of environmental assessments and environmental impact statements. e-NEPA can help project managers create this record through automatic organization of collaboration that takes place within the Web tool.

The e-NEPA tool improves collaboration within and among Federal, State, and local agencies to streamline required environmental reviews of transportation projects.

Piloting the Project

Five States tested e-NEPA as part of a pilot: Arizona, North Dakota, Utah, Washington, and Wisconsin. Other U.S. Department of Transportation modal administrations, such as the Federal Transit Administration and Federal Railroad Administration, also are participating in e-NEPA testing and using the tool for selected projects.

Melanie Vance, an environmental engineer with the Washington State Department of Transportation, participated in the e-NEPA pilot for her agency's Local Programs Office. "Many of our Federal partners are not allowed to use file transfer sites, so on past projects I have had to send out CDs with documents for review," she says. "e-NEPA's file sharing capabilities enabled us to coordinate within WSDOT and with others so we can easily share and review those documents from one common platform."

As part of the third round of EDC, FHWA staff members attended seven regional summits in late 2014 to promote e-NEPA and work with State departments of transportation to expand its use. FHWA will work with individual users to discuss how best to implement e-NEPA in their States and to set up training sessions with their project partners.

Streamlining NEPA project approval is a core need for the transportation community—to save time and money while improving the quality of NEPA documents. e-NEPA enables collaborative, concurrent, timely, and transparent interagency communication and review to meet those goals and to shorten project delivery times.

For more information about e-NEPA, contact Bill Ostrum at 202-366-4651 or william.f.ostrum@dot.gov.

Carrie Boris is a contributing editor for PUBLIC ROADS.

NATIONAL HIGHWAY INSTITUTE

Training Update

by Heather Shelsta

Shaking Up Geotechnical Training Delivery

On February 9, 1971, a magnitude 6.6 earthquake rocked the San Fernando Valley in southern California and wreaked havoc on the area's transportation infrastructure, causing an estimated $505 million in property damage. Following the earthquake, the highway community expended significant effort to develop comprehensive guidelines for the seismic design of bridges. That effort led to updates of both the American Association of State Highway and Transportation Officials' (AASHTO) and California Department of Transportation's design provisions. A number of guidelines and specifications have been published in the decades since, with updates occurring as often as every year or two.

To help highway and bridge designers and engineers stay current with the latest seismic techniques, the National Highway Institute (NHI) offers the 5-day Load and Resistance Factor Design (LRFD)-based course 132094 LRFD Seismic Analysis and Design of Transportation Structures, Features, and Foundations. In addition, NHI recently developed two shorter, 2-day courses as an alternative for those who prefer more flexibility in scheduling. These courses are 132094A LRFD Seismic Analysis and Design of Transportation Geotechnical Features and 132094B LRFD Seismic Analysis and Design of Structural Foundations and Earth Retaining Structures.

Course Highlights

Course 132094A LRFD Seismic Analysis and Design of Transportation Geotechnical Features addresses the earthquake engineering aspects of the original course. This comprehensive training covers seismic analysis and design of geotechnical features for transportation including ground motion characterization, site characterization, and identification of geotechnical seismic hazards. The course also includes analysis procedures for liquefaction and liquefaction-induced lateral spread or flow failures, seismic settlement analysis, and geotechnical hazard mitigation measures.

Course 132094B LRFD Seismic Analysis and Design of Structural Foundations and Earth Retaining Structures focuses on the seismic design of retaining walls and structural foundations. The course covers seismic analysis and design of geotechnical features for transportation including the interaction of soil, foundation, and structure; shallow and deep foundation design; and design of earth retaining structures such as free-standing retaining walls and abutment walls. The course also discusses interactions between geotechnical specialists and bridge design engineers in the seismic design process.

NHI developed these courses using the requirements and recommendations in AASHTO's *LRFD Bridge Design Specifications* and *Guide Specifications for LRFD Seismic Bridge Design*; the final report from National

C. E. Meyer, U.S. Geological Survey

The 1989 Loma Prieta earthquake damaged these concrete lane separators on California's Highway 17 and caused the landslide visible in the background. NHI's geotechnical training helps participants understand the risk factors and describes the latest structural technologies that can minimize damage.

Cooperative Highway Research Program Project 12-70 Seismic Analysis and Design of Retaining Walls, Buried Structures, Slopes, and Embankments; and the Federal Highway Administration's *Seismic Retrofitting Manual for Highway Structures* (FHWA-HRT-06-032 [Part 1] and FHWA-HRT-05-067 [Part2]).

A Resource for All Levels

Courses 132094A and 132094B are intended to engage an audience of bridge and geotechnical engineers with up to 20 years of experience, including those with little or no experience. Instruction methods include presentations, discussions, question-and-answer sessions, group activities, and hands-on exercises. At the end, participants undertake a group design exercise to reinforce learning and enhance the transfer of new skills and knowledge to the workplace.

Course participants gain a better understanding of the basis and limitations of the seismic design methods. They learn the practical skills needed to meet AASHTO's performance criteria for seismic design, such as assessment of site conditions, knowledge of key soil properties necessary for seismic analysis, and methods for evaluating those properties.

The prerequisite for both courses is the 4-hour, Web-based training 132010A Earthquake Engineering Fundamentals. The prerequisite consists of six lessons: Earthquake Fundamentals, Introduction to LRFD Seismic Design, Earthquake Ground Motions, Seismic Hazard Analysis, AASHTO Design Ground Motion Characterization, and Introduction to Geotechnical Hazards.

For more information, visit NHI's Web site at www.nhi.fhwa.dot.gov. To register for a session or to sign up to receive email alerts when sessions are scheduled, visit the course description page.

Heather Shelsta is the geotechnical training program manager for NHI.

Communication Product Updates

Compiled by Lisa Jackson of FHWA's Office of Corporate Research, Technology, and Innovation Management

Below are brief descriptions of communications products recently developed by the Federal Highway Administration's (FHWA) Office of Research, Development, and Technology. All of the reports are or will soon be available from the National Technical Information Service (NTIS). In some cases, limited copies of the communications products are available from FHWA's Research and Technology (R&T) Product Distribution Center (PDC).

When ordering from NTIS, include the NTIS publication number (PB number) and the publication title. You also may visit the NTIS Web site at www.ntis.gov to order publications online. Call NTIS for current prices. For customers outside the United States, Canada, and Mexico, the cost is usually double the listed price. Address requests to:

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For more information on R&T communications products available from FHWA, visit FHWA's Web site at www.fhwa.dot.gov, the FHWA Research Library at www.fhwa.dot.gov/research/library (or email fhwalibrary@dot.gov), or the National Transportation Library at ntl.bts.gov (or email library@dot.gov).

Intelligent Compaction (TechBrief)
Publication Number: FHWA-HIF-13-053

Intelligent compaction is an innovative pavement construction technology that equips conventional rollers with instrumentation to monitor and control the material compaction process. The technology, which is applicable to both soil/subbase and pavement compaction, provides graphical information that roller operators can use to better manage their operations. This ensures that the entire process provides a uniform compacted area that is achieved more efficiently. This technical brief offers information on the field application of the technology for asphalt pavements.

Thirteen States participated in the study, Accelerated Implementation of Intelligent Compaction Technology for Embankment Subgrade Soils, Aggregate Base, and Asphalt Pavement Materials. Sponsored by FHWA and the Transportation Pooled Fund, the study took place between 2008 and 2010 and aimed to demonstrate and evaluate intelligent compaction technologies. Of the 13 States, 10 participated in the field demonstration of asphalt pavement projects: Georgia, Indiana, Maryland, Minnesota, Mississippi, New York, Pennsylvania, Texas, Virginia, and Wisconsin.

The use of intelligent compaction was a success in all 10 States. Researchers found that intelligent compaction is very effective at achieving the target level of compaction for asphalt pavements while also increasing the uniformity of the compacted material. The roller demonstrations showed that intelligent compaction rollers could track and determine the optimum number of roller passes, monitor the surface temperature of asphalt pavements, and report measurements back to the operator to better control the compaction process. Also, researchers determined that a key factor in achieving uniform compaction in the final product is uniformity in compaction in the underlying layers.

This technical brief is available to download at www.fhwa.dot.gov/pavement/pub_details.cfm?id=920. Printed copies are available from the PDC.

Design Criteria for Adaptive Roadway Lighting (Report)
Publication Number: FHWA-HRT-14-051

About 50 percent of all fatal crashes occur at night, despite nighttime volumes representing approximately 25 percent of all traffic. Roadway lighting is a proven crash countermeasure on highways. With the development of new lighting technologies and a push to reduce the overall energy and environmental impact of lighting, adaptive lighting has become a new movement in the roadway industry.

Adaptive lighting is a design methodology in which the light output of a system adjusts as traffic conditions change. The level of lighting dims when there is little or no traffic on highways, sidewalks, or both. This report provides an approach to selecting and adjusting light levels based on the needs of the driving environment. The document also reviews the background and analysis used to develop criteria for implementing an adaptive lighting system for roadways.

Researchers collected lighting data from thousands of miles of roadway and compared the varying illumination levels, roadway characteristics, and traffic volumes with crash history information. A robust statistical analysis of the underlying relationships among these data revealed the effects and limits of lighting on overall roadway safety.

The researchers found that the relationship between actual lighting levels and safety was not as strong as in situations with no lighting. In other words, current lighting levels may be higher than required for safety on the roadway. By adapting the framework from existing international standards for lighting selection, researchers developed a method to provide both selection criteria for lighting levels and a method for determining how to implement adaptive lighting.

Researchers expect that the results will assist jurisdictions in making sound, safety-based decisions when considering adaptive lighting approaches. This analysis of real-world lighting data is intended to serve as the foundation for future analyses of roadway lighting.

This report is available to download at www.fhwa.dot.gov/publications/research/safety/14051/index.cfm. Printed copies are available from the PDC.

Correction

On page 31 in the July/August 2014 issue of PUBLIC ROADS, a State Farm logo was removed from the photo of a New York State Department of Transportation H.E.L.P. truck without the express permission of the photograph's owner, Dexter Davis of Travelers Marketing, Inc. Following is the original photo.

Dexter Davis. ©2009 Travelers Marketing LLC

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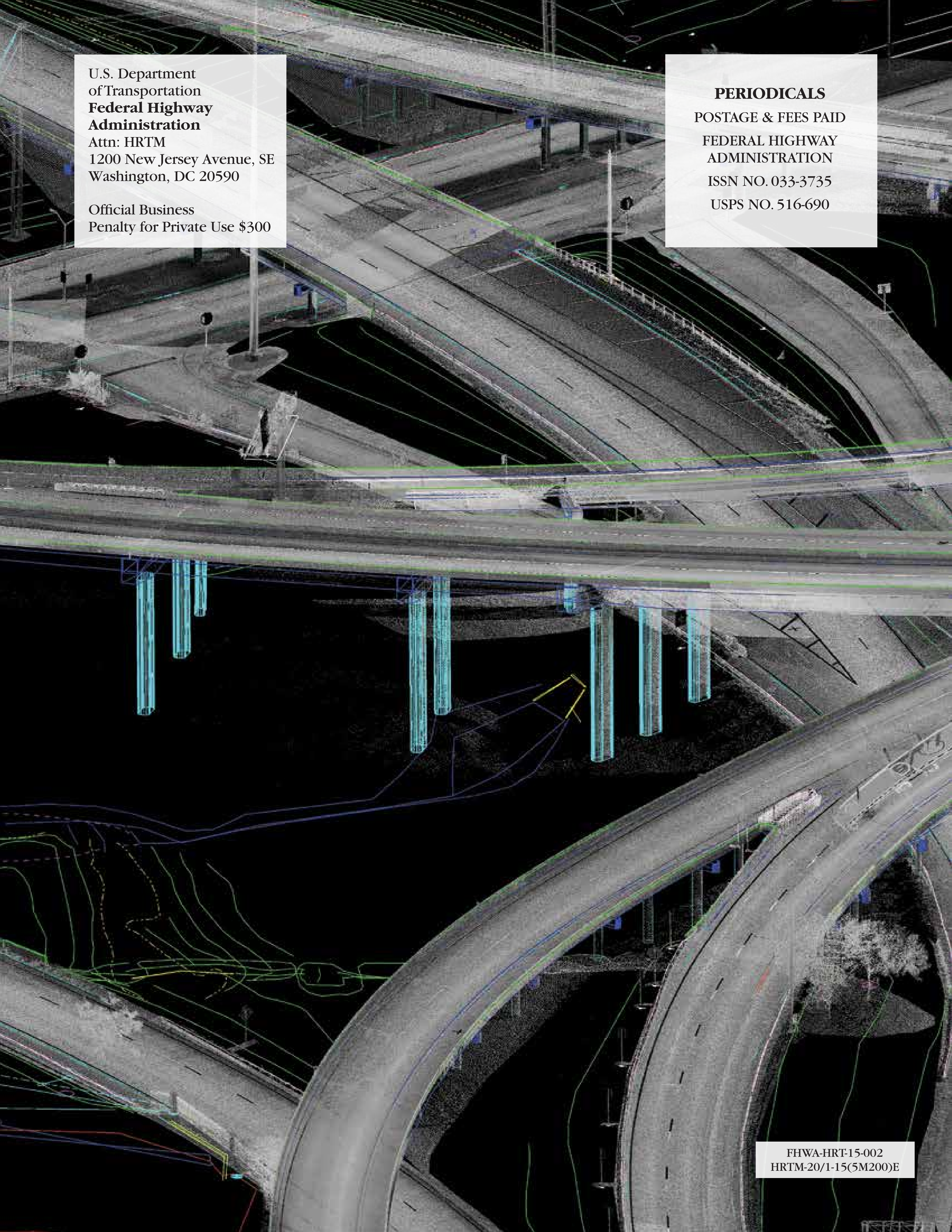

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